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Some Factors Associated with the Economic Feasibility of Reseeding Privately-Owned Cattle Ranges in Utah

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SOME FACTORS ASSOCIATED WITH THE ECONOMIC FEASIBILITY OF RESEEDING PRIVATELY-OWNED CATTLE RANGES IN UTAH

by

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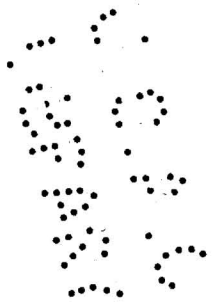

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TABLE OF CONTENTS

SOME FACTORS ASSOCIATED WITH THE ECONOMIC FEASIBILITY OF RESEEDING PRIVATELY-OWNED CATTLE RANGES IN UTAH

INTRODUCTION

The forage depletion of western ranges which has occurred during the past century is partly the result of the belief by ranchers that the forage loss was temporary and not serious. Should more forage of a high quality be desired they thought it could be produced by reseeding the ranges. The native western forages, never abundant or luxurious by eastern concepts, nevertheless were of generally high qualities. Limited by low and erratically distributed precipitation, the sparse native forages have in many areas given way to low quality plants. These plants of low quality do not have to withstand the adverse circumstances of both poor growing conditions and heavy grazing. In particularly severe cases an area has been almost completely denuded, exposing the soil to unchecked accellerated erosion.

The broken topography, which is typical of western ranges, has helped to intensify grazing pressures on the more accessible areas. During past ages the steep hillsides eroded to form depositions at their bases, forming bottom lands and meadows. It is these lower areas of intermediate elevation which are usually grazed first and heaviest. Animals converge in these accessible areas which are often readily available to water. While sheep are herded directly and graze different areas of a range under the management of a herder, cattle are left to roam at will with the exception of indirect controls such as location of water and salt and an occasional drift fence. Topography may be so steep that cattle are unable to graze the slopes. They are often unwilling to graze moderate slopes even though they have depleted the forages of the lower elevations. In addition, these lower areas may be winter ranges for deer and elk, animals which compete to some extent for forage with cattle and sheep. It is these conditions

which multiply the overgrazing effects on certain areas.

Recent literature originating from stockmen associations has claimed that drought is the principal factor causing depleted forage resources. This well may be an important causal factor. However, precipitation during the last decade, particularly in the West, has been favorable. Rather wide areas originally producing high quality forages are now producing luxurious growths of undesirable sagebrushes and annual grasses. Especially is this true of some intermediate elevational areas which have been grazed in the spring and again in the fall. Lack of government control on the open range has not encouraged stockmen to improve areas where the slogan "first come, first serve" has prevailed. When the benefits of conservative use did not accrue to the stockman using the range in a conservative manner, few attempts were made to maintain or improve the unadministered range. Denuded areas which have lost a part of the valuable topsoil have not responded appreciably to favorable climatic conditions. The western stockman, who believed the loss of quality forages was only temporary, has had to revise his opinions and search for a new method of reversing the downward trend of range capacity on areas which have lost their valuable forage species.

History of Range Reseeding in Utah and Adjacent States

A more or less haphazard experimentation program in artificial range reseeding has been carried on by stockmen and range investigators since the turn of the century. In 1923, Sampson was led to write concerning these programs (22, p. 39):

> "To produce a good crop of clover, timothy, orchardgrass or some other valuable grass where the annual rainfall is so low that "dry farming" of the most intensive kind fails to yield economical returns, would require a weird brand of magic."

Up to this time, except for the efforts of some of our earlier land agencies, little science was exercised in the programs. There were no

guides or procedures to follow because man had no previous experiences to rely upon. The importance of the science of ecology was just beginning to be understood in this new technique. Experimental plantings which were rather carefully planned generally ended in failure.

The severe drought of 1933-36 caused such widespread distress that an added impetus was given to range reseeding research. Relatively unlimited funds and personnel combined with a patience unhurried by fear of personal economic loss allowed the various federal agencies in the Departments of Agriculture and Interior to lay the foundations for techniques of range reseeding. Their work was greatly aided and supplemented by the discoveries of state agencies and by practical experiences of the Soil Conservation Service in its work of rehabilitating privately-owned farm lands. By 1944, rather well-defined procedures and recommendations had been formulated for wide areas east of the Rocky Mountains and for areas of specified site characteristics in the Intermountain Region. This latter area includes all or parts of Utah, Montana, Wyoming, Colorado, Idaho, Oregon and Nevada. In the 1947-48 fiscal year the public land agencies received a federal appropriation slightly in excess of a million dollars to conduct research and to reseed large areas in this region.

The financial aid offered by the Agricultural Adjustment Administration for range improvement had helped to encourage the private operator to attempt range reseeding. When governmental demonstration areas had been successfully reseeded, the recommended procedures were eagerly seized upon and tested. There were some failures, but as a whole, the range reseeding program has continued its past trend of increasing public popularity.

Present Status of Range Reseeding Research in the Intermountain Region

Present research has been designed to answer the questions of where,

what, when and how to reseed, and after the seeding, how to manage the area. As can be seen from this foregoing statement, it has been the physical aspects of reseeding which have necessarily been the prime consideration for investigation. However, with the advent of the private operator into the program, an increasing question of "how much?" has been raised. Included in this last question were also queries as to chances of success of the experiment.

On an experimental basis government and state agencies have striven to reseed nearly all possible sites, using all possible kinds of seeds in combination with many variations in planting techniques. Site characteristics of soil quality, climate and topography have been correlated with types of seed and seed mixtures to give the most favorable results. Exotic seeds have been introduced in an attempt to establish stands on areas either too dry, too wet, too cold or too hot for native plants. The introduction of Crested wheatgrass (Agropyron cristatum (L) Beav.) from Asia has been a boon to the western cattle producer. In the Intermountain region he has apparently used this grass species more than any other or all other grasses combined in his programs because of its wide range and drought resistant characteristics (11).

Reseeding research in Utah generally has been confined to high and medium elevational areas. Soils are fair to good and precipitation is moderate to heavy as compared to the lower areas. With proven techniques in favorable locations it has been possible by refining these techniques to apply them to less favorable sites. Also it has been the intermediate zones which have suffered the most from overgrazing, hence the urgency for research.

Various estimates have been made of the extent of areas which could

now be reseeded using methods already proven. In 1944, Stewart (24) estimated a total of 5 million acres, about 1 million acres of abandoned cropland and four million acres of brush land now producing little forage, were suitable for reseeding in Utah alone. This same author and others (25) estimated that of the 12 million acres which will need to be revegetated in the Intermountain area, approximately one-half lies in the spring-fall zone. Friedrich estimated in 1947 that approximately 1½ million acres had been successfully reseeded on or near the national forests in Montana (3). Writing of the western range area, other investigators (16) have estimated that 80 million acres are so depleted that reseeding will be necessary to rehabilitate these areas. They estimated that approximately 5 million acres had been reseeded up to 1948.

PHYSICAL FACTORS

Site Requirements

In the arid West precipitation is of prime importance in the consideration of site requirements for range reseeding (28). Of equal importance with both amount and distribution of precipitation is the temperature as it influences evaporation. Evaporation, which is dependent on a variety of conditions, generally exceeds precipitation during a given period. The topography of the western range is so varied that annual total precipitation ranges from about 5 inches to 50 inches (3). Altitudinal differences account for much of this great variation.

Precipitation records were collected for stations adjoining reseeded areas and for Utah State as a whole. It is readily apparent from Figure 1, which represents the October 1st through September 30th totals for the state over a 48-year period, that the latter portion of the record, which includes the period covered by this report, was well above normal with

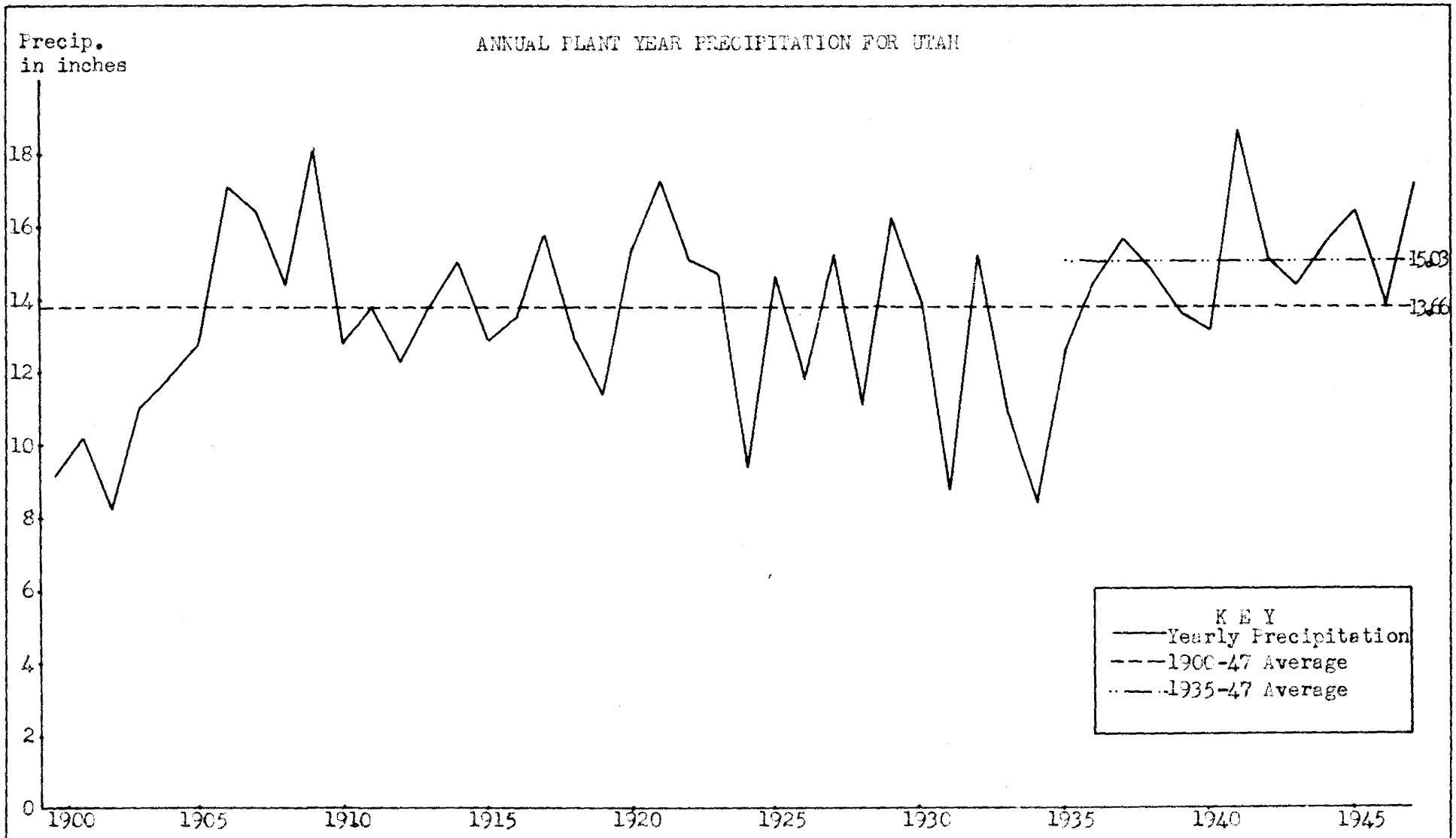

Figure 1: The annual plant year precipitation for Utah State represents the average precipitation for all stations falling from October 1st through September 30th. The annual totals varied greatly with wide fluctuations and serious cumulative effects. However, the period 1935-47 had a marked cumulative total over the average.

virtually no reading below the long-time mean. A short-time average, the period 1935 through 1947, was 1.37 inches above the long-time average, or an increase of 10 percent. This period tended to be favorable for the reseeding operation since the amount of moisture available in the soil can be considered to be as important to the success of the reseeding enterprise as the current amounts of precipitation.

An analysis was attempted to measure the relative severity of droughts by the methods as advanced by Clawson and Hochmuth (2). The terminal figure, designated "Coefficient of Variability Sequence", is a measure of the average number of years during which the annual precipitation will make a movement up or down. Since four movements are necessary to complete a cycle, then by multiplying the coefficient by four will give the average number of years necessary to complete the cycle in any one locality. As the number of years in a cycle increases, then the more severe a drought will be when it occurs. Also, it can be assumed soil moisture will vary more widely from the average in areas with a high coefficient than in areas with a low one. Calculations of this value for different stations are represented in Tables 19 through 24 in the Appendix.

Soils are perhaps even more varied than precipitation although of a slightly lesser significance in reseeding site selection. No blanket recommendations can be made concerning reseeding without first considering precipitation in combination with soil type. The mountain soils are usually coarse with thin top soils and porous subsoils. The lower slopes and higher level areas, which have resulted from depositions from steep mountainous areas, generally have sandy and gravelly soils that are well-drained. The deep well-drained alluvial soils of the upper valley zones are the best agricultural soils and, where it is possible to develop water

for them, may be cultivated. The valley-bottom soils are heavier, usually more poorly drained and excessively alkaline in comparison with higher areas.

Research in range reseeding has progressed to where a fair amount of success may result from a reseeding program which includes carefully selected sites having favorable climate and soil characteristics. Too often a series of years with more than normal precipitation has encouraged a reseeding of wide areas with only mediocre to poor soils. Such programs were not based on a careful consideration of soils and long-time precipitational characteristics. They have often resulted in failures with high losses of funds and reduced confidence in the programs. This situation is comparable to past dryland wheat farming expansions under good precipitation and then subsequent failure with reduced moisture.

Only sites which are strategically located in the seasonal livestock programs have been reseeded on privately-owned cattle ranges. In addition, sites have been selected where the amounts of desirable plants are so drastically reduced or suppressed that a short deferment period would not allow an appreciable recovery. It has been the practice to select the better sites for first priority. Such sites must have reasonably good soils with at least 11 to 12 inches of precipitation annually (24)(25)(28). To be more economically feasible they should probably be in areas which are in short supply for the completion of the seasonal grazing program. Caution must always be exercised by the cattle rancher when successes resulting from careful site selections have led him to broaden plans for larger areas.

Seasonality of Range Reseeding

The elevational differences in the Intermountain area have caused a dividing up of the range operation by seasons. The higher areas are covered with deep snows nearly half of the year and are therefore available

only during the summer and early fall months for grazing. At the other extreme are the desert lands which are too hot and dry for advantageous grazing during the summer. Fortunately, most desert areas usually experience only a temporary and light blanket of snow during the winter, allowing a use of the native desert forages during that period. Melting snow and occasional rains provide water for the grazing animals. The two areas are often far apart and are of necessity separated by a transitional area of moderate altitude. It is this area which is grazed in the spring before the snows melt in the summer on high ranges, and again in the fall before the late autumnal rains or snows allow a grazing of arid desert ranges. In Utah a fair balance exists between summer and winter ranges with spring-fall ranges being at a premium. Since large portions of summer and winter ranges are publicly owned, dates are set by public officials depending on readiness of the range for grazing. When an early fall on higher ranges is followed by a late winter on winter ranges the private rancher is forced to hold his herds on an insufficient amount of spring-fall range for extended periods. As a result of the almost univeral bad condition of these ranges in Utah, it is here that private reseeding operations have taken first priority.

Precipitation occurs mostly during the winter in the form of snow. Fall and spring rains do occur but are not dependable. Most authorities recommend that seeding be done either in late fall or early spring (16) (21)(27). This is recommended to take advantage of a maximum amount of moisture in the soil during the early critical growth of the reseeded plant seed after germination.

Another aspect of the seasonality of range reseeding is the way in which the reseeding operation competes with other regular ranch duties for

the operator's labor. The late fall schedule fits in fairly well with the yearly routine of ranch duties. It occurs approximately as the cattle have begun to graze the crop aftermath before the winter feeding period. Spring seeding is not as favorable, for the rancher's first concern is his spring plowing.

Seedbed Preparation

In the preparation of a seedbed the first problem of the rancher is the elimination of undesirable native vegetation. If it is extremely heavy, it will be necessary to eliminate all or a part of the present cover of vegetation to prevent competition between the well-established plants and the reseeded grasses. This may be done by burning, railing or plowing with special type plows.

Burning, although the cheapest method of removing heavy stands of sagebrushes, has received a bad reputation because of indescriminate and uncontrolled burning (27). Burning must be carefully controlled on limited areas under definite climatic conditions or a disasterous fire may result which will destroy all protective plant cover (17).

Railing is a method of partially eliminating competing vegetation by dragging a heavy railroad rail over the plants. This method is effective when plants of the brush type are relatively dry and where a complete destruction of native plants is not desired. Oftentimes a few valuable forage grasses may be scattered throughout the brush which might help to revegetate the area. Also, enough brush may be desired to partially protect the area when a danger of accellerated erosion exists. Railing may be combined with the seeding operation when a broadcaster scatters seed between the power unit and the rails. A dixie drag, a set of heavy tubular posts containing steel pegs set at right angles to the posts, is sometimes

substituted for the railing.

Intensive soil preparation was originally ignored because of the wide areas to be reseeded plus the often steep topography and rocky soils included in the selected sites. The degree to which plowing, disking and harrowing is used should depend on plant cover and type of soil. It has been stated that the best seedbed is one which has one or two inches of loose and fine-textured soil over a deep firm soil base (25). When annual grasses and brush are present it is often necessary to disk or even plow the area (4). Some ranchers prefer a partial preparation whereby regularly-spaced contour furrows are made by special furrowing machines. In this operation a seeding attachment also allows the seed to be planted in the furrow in the one operation. This method is recommended by agencies interested in the prevention of soil erosion. The contour furrows are particularly effective in preventing water erosion.

In some of the better sites private ranchers have seeded a rye or wheat crop one or several years previous to or along with the pasture seed. This has allowed the fast growing grain to render a harvest to help pay for the reseeding cost, suppress competition of native vegetation and provide protection to temporarily exposed soil.

The Range Seed Situation

Commercial seed dealers have in recent years stocked a wide variety of commercial grass seeds. Two commercial seed houses in Salt Lake City, Utah have sent out seasonal catalogs of farm seeds which included sections on native range seeds. The supply of seeds varies from year to year depending on growing conditions and the demand for seed during the previous year. In Figure 2 stocks of four popular western range seeds held by dealers and government on June 30th during recent years has been charted to show the

COST AND SUPPLY OF FOUR POPULAR WESTERN RANGE GRASS SEEDS

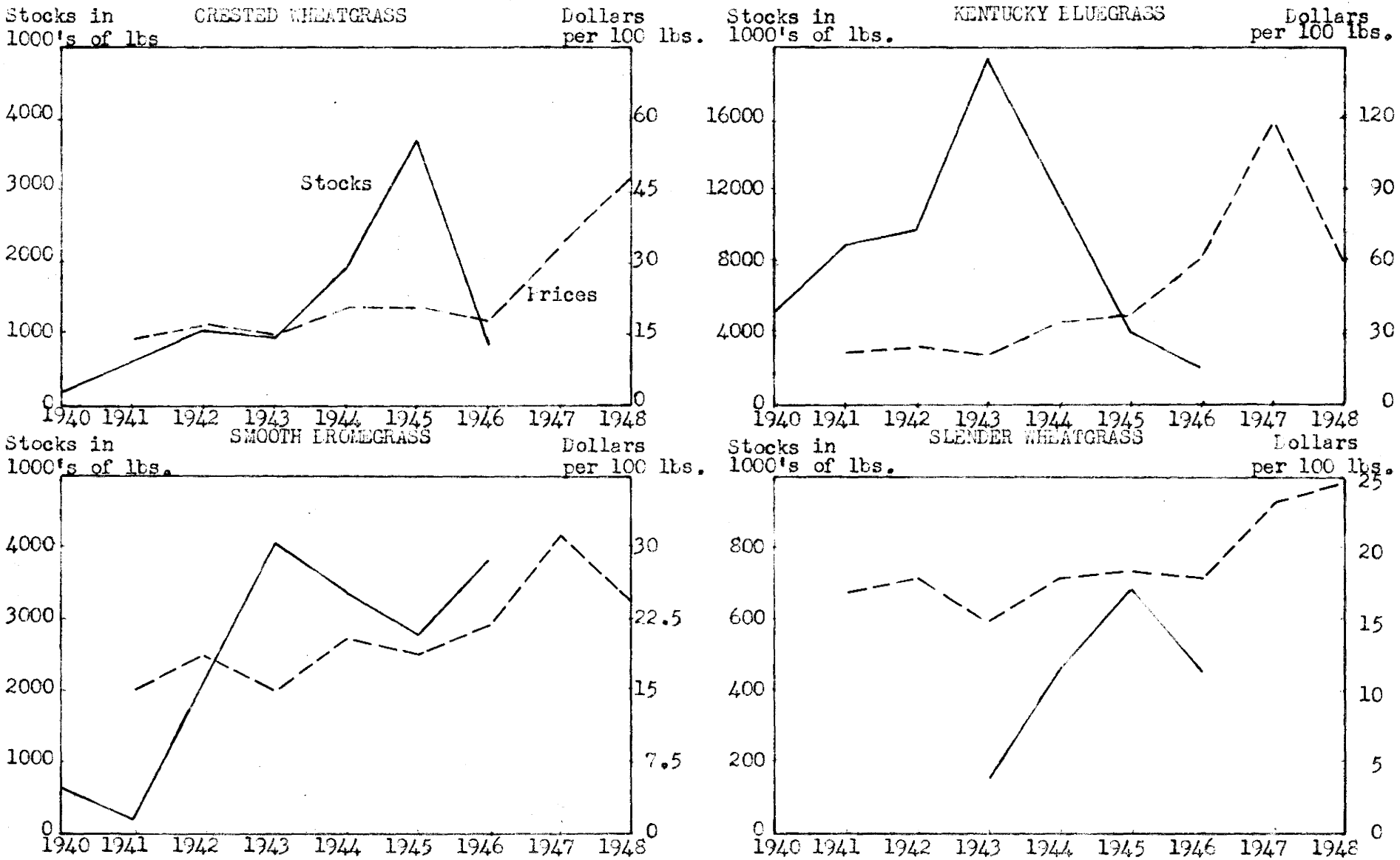

Figure 2: The demand for seeds probably influences price to such an extent that in the cases of Crested wheatgrass, Smooth bromegrass and Slender wheatgrass the supply is a further reflection of that demand. The supply of Kentucky bluegrass is extremely large so as to satisfy the steady annual demand for lawngrass seed, allowing an inverse relationship between supply and price.

Source : Ag. Statistics, 1947 and Monthly Seed Listings of Kelley Western Seed Co., Salt Lake City, Utah

variations in supply. To bring out relationships between supply and price, the price quoted by one of the above Utah dealers was included.

It has been possible to procure most of the better known seed species through these dealers in recent years. However, should the seed be a newly introduced one or should an older seed experience a sudden wide popularity, the lag in supply may cause a seed species to be temporarily unavailable.

It has been possible to harvest some types of seed by hand from the plants growing in the wild state. This practice is generally slow, tedious and expensive. Hand collecting of seed is the general procedure when a small supply of a species previously unused by researchers is desired for experimental plots (8).

Commercial pasture mixtures have been available for range reseeding. Although it is reasonable to suppose that a combination of requirements in a seed mixture would allow the mixture to take advantage of a large part of the site qualities, on spring-fall ranges mixtures have generally contained some seed species which are suitable only for moister situations.

In general, seeds should not exceed two years of age and should be raised in the same general area and under as near a duplication of growing conditions of the final reseeded area as possible. The seeds of different species vary in their viabilities after periods of storage. In the past, seeds with low germination percentages have been an extremely large factor in the failures of reseeding operations (9). Tests of germination on native grass seeds showed a moderate to low percentage of germination (27).

Table 1 lists 17 species of plants which have met at least partial success in reseeding trials in the Intermountain area. Relative qualities and requirements are given for each plant.

The machinery used in seeding consists of broadcasters, grain drills,

Table 1: Some of the More Popular Western Range and Pasture Species, Showing Their Site Requirements, Recommended Seeding Rates, and Growth and Capacity characteristics

Grass Species	Climatic Adaptation	Soil Adaptation	Site Adaptation	Time of Seeding	Rate of Seeding Per Acre	Palatability	Grazing Capacity	Growth Character
Slender wheatgrass	Drought resistant	Loams, Alkali-tolerant	Mountains	Fall or early Spring	5-12 pounds	Cattle and horses	Susceptible to trampling	Slow
Bluestem wheatgrass	Hardy, drought resistant	High alkali, silt loams	Bottoms, sage-wheatgrass	Fall or early Spring	8-15 pounds	All Cures well	Less than Crested wheat	Open sod Bad seed
Bluebunch wheatgrass	Drought and cold resistant	Poor soils	Medium zone	Fall or early Spring	5-12 pounds	All Some sheep	Trampling	Bad seed 1-3 feet high
Crested wheatgrass	Drought and cold resistant	Productive All	Foothill and low mountain	Fall or early Spring	3-8 pounds	All Good pasture	High yield with high use	Very early growth
Smooth bromegrass	Low rainfall moderate hot	Loams and clays	Aspen zone	Fall or early Spring	8-15 pounds	All	High yield	Very early growth
Mountain bromegrass	Cool and moist	Loams to poor	Aspen and higher	Fall to Midsummer	10-15 pounds	All except sheep at maturity	Moderate	Good seed
Tall oatgrass	High temperature	Deep soils	Shade intolerant	Fall or early Spring	8-15 pounds	Only when familiar with	High	Poor seed Long green
Meadow fescue	Cool, humid	Wet soils	Mountain meadow	Fall or early Spring	8-15 pounds	All	Moderate	Best in mixtures
Sheep fescue	Highly drought resistant	Poor and sandy	Dry foothills	Fall or early Spring	3-8 pounds	High sheep	Close grazing	Bunchgrass
Kentucky bluegrass	Moderately cool, moist	Rich drained	Moist mountain	Fall or early Spring	5-10 pounds	All	Early spring Late fall	Long-lived Slow
Canada bluegrass	Drought, heat resistant	Thin soils Rocky	Drier Sunny	Fall or early Spring	5-10 pounds	All, close grazing	Close grazing	Tough sod
Bulbous bluegrass	Moderate	Sandy loams to clays	Medium moist	Early fall	5-10 pounds	High	Medium to low	Spring and fall growth
Perennial, Italian ryegrass	Moist, mild winters	Rich soils	Moist, well-drained	Early spring	8-15 pounds	High	Large for 1-2 years	Short-lived Rapid growth
Timothy	Cool, humid	Fine-textured	Moist mountain meadow	Fall or early Spring	8-12 pounds Mixture best	All	High	Established quickly
Orchard grass	Less cool Moist	Clays	Shady and moderately moist	Fall or early Spring	5-10 pounds Mixture best	Medium to high	Graze early	Early and late
Rye	Cool climate Hard winter	Well on poor soils	Foothill and mountain	Late summer and fall	30-60 pounds 20 in mixt.	High	Good fall and spring	Annual early
Alfalfa	Semiarid	Deep, fertile	Favorable, abandoned	Early spring Innoculate	5-10 pounds	Very high	High without close grazing	Perennial Deep root

single and double disk drills, and deep furrow drills. Most authorities agree that the seed should be covered in the planting operation (25)(26)(27). With the exception of the broadcasters the tendency has been to plant the very small grass seeds too deep. Depending on the looseness and texture of the soil and type of seed, it has been recommended that plantings should not be deeper than 1 inch and preferably around one-half inch (16)(27). Broadcasted seeds may be covered by drags or rails, by sowing seeds in the ashes of fresh burns, or by sowing under broad-leaved trees prior to leaf fall. A recent method has been to enclose the seeds in pellets which, as soon as they become damp, allow the coverings of clay to soften and presumably act as a cover for the enclosed seeds.

Drilling can be accomplished by blocking every second or third opening of an ordinary grain drill. Agitators should be used to assure uniform seeding. Care should be taken not to plant too deep.

In furrow planting the disks should be set so that just enough soil is allowed back in the furrow to cover the seed. Furrowing is recommended on steeper and drier areas of the range. Besides helping to contour the area the furrow concentrates the runoff water on the seed. In some areas where the wind is fairly constant the seed may be left uncovered in the furrow. The wind blowing across the fresh furrow will blow soil over the seed.

Airplane seeding has been attempted on extensive areas in southern Idaho from 1938 to the present time (10). Seedbed preparation can be made only with extreme difficulty when large and rough areas are seeded. By seeding in burns the seeds are oftentimes covered by ashes. Seeding just prior to cold weather in the fall permits some seeds to be covered by the expansion and contraction of the soil during the freezing and thawing of the ground. Sheep have been driven through reseeded areas, helping to

plant seed by trampling them in. One difficulty in range reseeding by air is the uneven distribution of seeds. The seeds are so light or the mixtures contain seeds of such varying weights that air currents concentrate or disperse them in various areas as they are falling. The pelletized seed mentioned above seems to have overcome this difficulty.

Broadcasting by cyclone seeders from horses or off the rear of tractors and wagons has been quite extensively used. When drags are used to help cover the seeds, a much larger chance of success exists than if no attempt was made to cover them. Broadcasting with no subsequent treatment is sometimes effective on fresh-plowed ground.

Management During and After Reseeding

One essential requisite to the establishment and maintenance of a good stand is deferment of the area from all grazing animals until the plants have become well established (25)(26)(27)(28). It is recommended that the area be deferred for several years, but few ranchers can afford to delay use for lengthy periods. At any rate, the area should not be grazed the following growing season and preferably only lightly grazed during the second season following reseeding. In Utah it has been the general practice to graze over the area lightly the second year after the seeding, followed by full capacity grazing on succeeding years.

Range Reseeding Constructions

Cattle will travel long distances, particularly if the forage is poor, to graze the young grasses on reseeded areas. To prevent this, fencing constructions must often be made. On large areas fencing costs are prohibitive if it becomes necessary to enclose the entire area. By control of salt and water within the surrounding area and by taking advantage of every natural barrier by a partial fencing it is often possible to make

a minimum expenditure for fencing. In some cases where no precautions were taken, nearly every rancher contacted stated that trespassing cattle had seriously hindered the establishment of grasses on the reseeded areas.

Watering facility developments in the range reseeding programs were kept to a minimum. The areas were small enough so that they did not drastically change the grazing plan. Since reseeded areas were generally on high mountain flats or upper valley areas, they were generally adjacent to water.

General Recommendations in Considering the Physical Factors

In summing up the physical factors in range reseeding 8 general recommendations have been advanced (26). These are:

1. Reseed key areas with soils intact where forage is so depleted to preclude rapid recovery.
2. Reseed sites which have better soils, moisture, topography and related factors.
3. Remove the competing vegetation and prepare the soil so as to give the greatest advantage to successful seed germination and survival.
4. Plant good seeds of the species best suited for the site.
5. Provide a good seed distribution.
6. Plant seed at the proper depth.
7. Plant so that newly germinated seed will have favorable moisture and temperature conditions for at least one or two months.
8. Graze the stand moderately only when the plants are well established.

ECONOMIC FACTORS IN RANGE RESEEDING

Need of the Study and Review of Literature

The individual rancher of Utah, after observing the favorable results

of range reseeding research, has attempted to reseed approximately 180,000 acres of range under the AAA program during the period 1940-46. Some ranchers have realized a good stand of grass with a moderate increase in capacity. Apparently no attempt has been made by these ranchers to measure and compare either investments in the operations or returns from them among themselves. In a preliminary investigation by the U.S. Forest Service, a partial analysis of investments in artificial reseeding was reported (21). The study was purposely fragmentary, dealing only with two ranches. Apparently an effort was made to determine if governmental and private investments in reseeding were comparable.

Before private ranchers of Utah will proceed with confidence to reseed range, some of the uncertainty caused by varying investment amounts and return data in published governmental reports should be resolved. This can be accomplished by a study of investments in and returns from range reseeding as experienced in the private reseeding operation. Since there are apparently no reports on this subject which might apply directly to private lands in Utah, the following descriptive study has been attempted. Its purpose will be to describe the results of an economic survey of range reseeding as carried out by Utah range cattle raisers.

Included in most recent works on range reseeding has been a cost of reseeding section. In general, the investments varied directly with amounts of competing vegetation in the area, topography and degree of seeding and seedbed preparation. On cheatgrass (Bromus tectorum L.) lands in the Northern Rocky Mountain area, where it is necessary to completely plow, harrow, pack and drill the seed into the ground, Friedrich (3) found that a crested wheatgrass planting resulted in an investment of from $5 to $7 per acre in 1946. Pearse and Hull (15) made an investment and return analysis of reseeding on level brush-free lands at Malad, Idaho in 1937

and Ephraim, Utah in 1939. They were able, by assigning a value to an animal unit month of grazing based on prevailing rates, to arrive at values for total gains in capacities. By including a 40 percent of cost contingency expense for possible failures, investments in the two areas for reseeding were $4.48 and $2.58 per acre. The total annual gain in grazing value was $1.53 and $1.46, respectively. By increasing the contingency rate to 60 percent, total investments per acre of $5.12 and $2.94 were calculated. They also made estimates of investments which would result from preparing sites for reseeding on areas varying in degree of slope and amount of cover in the Intermountain area. On level or rolling lands investments for site preparation, seed and deferment were estimated to total $1.45 and $2.25 per acre on brush-free and brushy lands, respectively. On slopes from 30 to 60 percent the investment estimates were $1.40 and $3.65 under the above two degrees of plant cover when the treatment included 50 percent of the area.

Stewart, Walker and Price (25) made estimates of the investments in reseeding per acre under varying conditions and varying methods of preparing seedbeds and sowing. Since the investment estimates were only approximations, no totals were given. However, by adding the lowest and highest estimates, total investment in reseeding on Intermountain range lands ranged from $0.93 to $7.10 per acre, depending on degree of seedbed preparation and seeding rate.

From an analysis of reseeding on oak-brush ranges in Utah, Price estimated (19) that the investment in seeding range lands by broadcasting, not including seed costs, would range from $0.65 on land with no prior or subsequent treatment to $6.00 per acre when the soil was prepared by plowing furrows three feet apart and the seed covered by a brush drag. Stoddart and

Smith (27), in an analysis of Price's statistics, applied investments in and returns from a 50-acre tract and obtained total investment of $390 and returns of 4.08 cow months increase in capacity. By assuming the value of money at 3 percent they were able to arrive at a return of $11.70, which would be necessary to cover the annual costs. On the basis of the increase in capacity, each cow month of additional grazing which was realized would have cost $2.87. Since grazing privileges on adjacent private lands was valued at only $0.50 per cow month, they concluded that the net return from the standpoint of annual cost and grazing return alone was negative. The conclusion of these authors was that only the most favorable sites can be reseeded at a profit. Intensive cultivation with a complete coverage of land using high-priced seed rarely was thought to be justified.

Scope of the Study

This study dealt exclusively with the artificial reseeding of cattle ranges in Utah. There was no limitation set on the size of the reseeded area. However, the areas were not considered range lands if they were irrigated. Although no attempt was made to set time limits, all the data represented a period subsequent to 1937.

Procedure of the Study

The data were collected by the survey method. A survey questionnaire form was designed by the Bureau of Agricultural Economics. The study was made under the supervision of BAE and was included in a broader preliminary study entitled "Farm Utilization of Home-Grown Feeds".

A sample of Utah ranchers was selected by contacting the agencies of the state and federal governments concerned with range improvement practices. A list as complete as possible was compiled from these and other sources. No random sample was prepared. By contacting county officials it was possible to select from the list ranchers who had actually attempted a reseeding

program and who were at the particular time available for an interview. It was found that a random sample resulted in the inclusion of a large percentage of ranchers who had either died in the meantime, left the cattle business or who were at the time unavailable for an interview. Although it was not possible to visit every county in the state, an attempt was made to visit enough of the state to afford a representative sample. The locations of areas on which investment data was received are indicated in Figure 3.

Approximately 50 ranchers willing to give an interview were contacted. It was found that more often than not the information which was necessary for a legitimate estimate of investment and returns was not forthcoming, either because of reluctance to discuss the operation or more often because the rancher had never before had occasion to think of his reseeding enterprise on an investment and return basis. Where AAA payments for seed, plowing or constructions were made, investment information was fairly well itemized.

Investment data on 21 areas were received from 18 ranchers. The combined areas consisted of 5226 acres. Return data were available for 12 of these 21 areas, comprising 2616 acres. The difference in sizes of the investment and return areas was caused by inability to calculate a net return because some of the areas reseeded had been used previously by sheep or for dryland wheat crops or the area had not yet been grazed after reseeding. A general table of organization (Table 2) is included to familiarize the reader with the general conditions surrounding the reseeding operations.

In all probability bias may exist in the data. Range reseeding is a new and advanced method which has not yet met with universal acceptance. It can be safely assumed that only the alert and more progressive individuals

LOCATION OF PRIVATELY-OWNED RESEEDED CATTLE RANGES IN UTAH
THAT ARE INCLUDED IN THIS STUDY

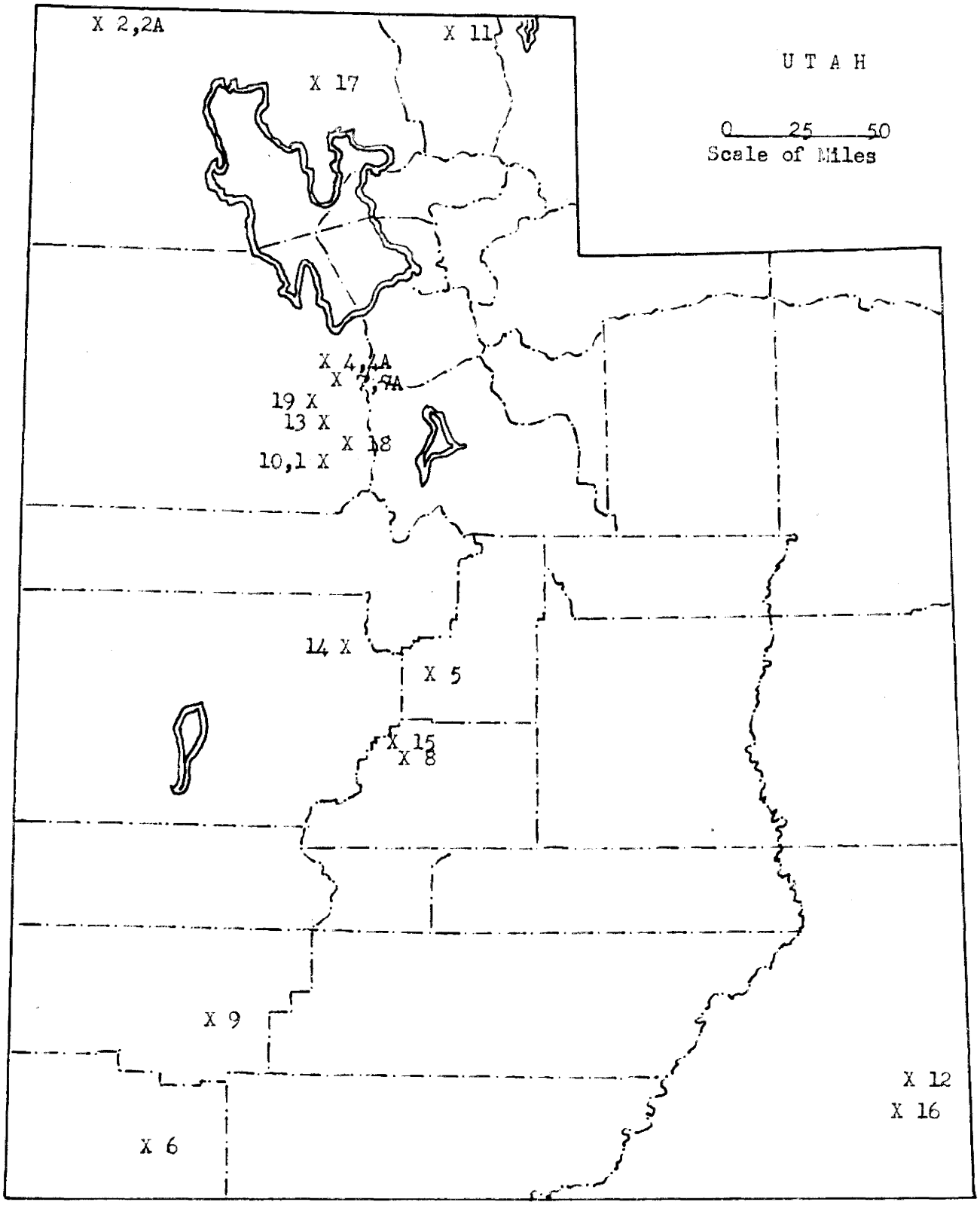

Figure 3: The "X's" which are identified by a number representing a particular rancher are reseeded areas located approximately as they occur throughout the state.

Table 2: Table of Organization for Utah Ranches Practicing Range Reseeding Included in Study

Rancher	Location	Year Reseeded	Acres in Ranch	Number of Cows	Acres of Cropland	Acres of Rangeland	Total Acres Reseeded	Percent Reseeding is of Rangeland
		Year	Acres	Cows	Acres	Acres	Acres	Percent
1	Vernon	1944-45	185	38	37	148	105	71
2	Lynn	1938	4,000	200	230	3,770	8	0
4	Tooele	1939-43	7,000	60	2,300	4,700	640	14
5	Centerfield	1940	700	100	0	700	20	3
6	Hurricane	1946	1,000	55	0	1,000	60	6
7	Tooele	1944-45	10,000	250	300	9,700	600	6
8	Salina	1940-42	10,000	500	150	9,850	50	1
9	Little Valley	1944-46	1/	--	--	--	--	--
10	Vernon	1942	1,800	80	90	1,710	50	3
11	Smithfield	1947	1,160	200	340	820	200	24
12	Monticello	1946	1,500	40	500	1,000	20	2
13	Vernon	1943-44	1,200	80	150	1,050	17	2
14	Scipio	1944-45	12,500	300	500	12,000	1,500	12
15	Salina	1939	2,200	56	504	1,696	160	9
16	Monticello	1946	740	20	200	540	53	10
17	Pensel Valley	1947	32,000	700	1,700	30,300	1,450	5
18	Vernon	1947	1,500	40	60	1,440	115	8
19	St. John	1938	5,000	400	600	4,400	200	5
Total			92,485	3,119	7,661	84,824	5,248	
Average			5,440	183	450	4,990	309	6

1/ Area reseeded cooperatively by a grazing association. 4,000 acres reseeded.

will have tried this technique. Results from these superior individuals are probably somewhat better than those which could be expected from the average rancher. A compensating factor could be that as more average ranchers practice a reseeding program, techniques will have improved to allow better results.

The sampling of ranchers which was made could have been biased. Allowing persons who were familiar with the areas to eliminate ranchers from the sample may have caused the exclusion of an undue number of areas with poor results. However, the fact that failures were recorded lends some weight against the belief of a large bias toward selecting areas only with favorable results.

General Economic Considerations of the Cattle Rancher in Utah

It would not be possible to measure all the benefits from the range reseeding program. Besides the obvious advantage of a relatively rapid increase in capacity of the range and condition of grazing animals on successfully reseeded sites, Short (23) listed three indirect advantages of reseeding. These were that reseeded acres (a) tended to stabilize the livestock industry by providing a more dependable type of forage, (b) they increased the esthetic values of the area and (c) they conserved both soil and water by reducing runoff and erosion. It is conceivable that besides these indirect advantages, more concrete advantages other than grazing gains may make feasible a reseeding project having a large initial investment. An example of this would be the necessity to increase the forage for a particular seasonal range so as to balance the enterprise. Another case would be the establishment of breeding pastures to assure good conditions during the breeding season. In rare cases it may be necessary to separate purebred animals from range livestock. It is

reasonable to suppose that fencing costs could be kept to a minimum if small high-producing reseeded areas were fenced to maintain these animals.

Obviously, it would not be possible to measure all the beneficial effects of the range reseeding program. Government reseeding programs have been designed in some cases primarily for flood and erosion control. Government officials have long been aware of the indispensibility of a good cover of grass or trees for the controlling of erosion on sloping lands. Grass has been determined as being essential on most soils as a soil-preserving force. Besides binding the soil, grass helps the water to infiltrate into the soil rather than allowing it to run over the land as surface water, causing accellerated erosion. Private ranchers have only in extreme cases attempted a reseeding program for reasons other than to increase returns from the livestock enterprise. Necessarily, these returns must begin to be realized in a relatively short number of years. Although the private rancher can appreciate the long-time benefits to society of a continuous and steady supply of water from his ranges, he may seldom if ever attempt a program for which he has to pay without a reasonable prospect of a net return. He will manage his enterprise so as to realize the maximum return over a period of time which he deems necessary.

The study was designed only to measure the investments in the reseeding programs, the returns from them measured in increased grazing capacities and gains of marketable animals. Any further measures of returns would necessitate a greatly enlarged and detailed study of the ranch organization. Also, it would be necessary to make current physical measures of productivity through a period of years. This study had neither the scope nor time and personnel to make these objective measures. Rather, the results

were tabulated from the estimates of ranchers who had a minimum opportunity to consider the matter beforehand.

It is almost as difficult to measure the true investment in range reseeding. Any type of construction or other improvement taking place as a result of the reseeding operation will probably benefit adjoining and other areas to various degrees. Under a rigid budgeting system, which was not possible to pursue in this study, the investment in an improvement should probably be divided and charged to the areas or enterprises receiving the benefits.

The reseeding projects on private lands usually are found on fairly level land in areas not too inaccessible by road. An examination of unpublished data on 14 governmental reseeding projects in the Intermountain area in 1947 showed the areas varied from 0 percent slope to an extremely steep area of from 30 to 80 percent. A majority of the areas ranged from 5 to 30 percent slope. The projects ranged from 4 miles to 100 miles from the bases of operations, with 25 miles distance being the most common. Investments in hauling and moving ranged from $0.05 to $2.26 per acre, with $0.30 being about average. In three of the 14 projects it was necessary to build roads into the areas costing from $115 to $1177. These expenditures greatly increase the investment per acre. Few ranchers could afford such programs except on extremely critical areas.

Another consideration which the rancher must face is the availability of equipment for the operation. Although detailed statistics on farm equipment ownerships are not available for Utah, it has been determined that the average Intermountain cattle ranch during the period 1930 through 1947 included from 8.2 acres in 1941 to 51.6 acres in 1934 of cultivated land, most of which was in grains (6). It is anticipated that a majority

of the farmers in Utah would have either tractor or horses plus suitable plowing, harrowing and seeding equipment to enable them to cultivate the grain acreages. Between the period 1940 and 1945 the Agricultural Census of 1945, as quoted by Hibbard (7), showed the amount of plowing by tractor in Utah had doubled. This statement further supports the belief that ranchers have the basic equipment available to them for a reseeding program. The Soil Conservation Service has cooperated with the Soil Conservation Districts of the state in loaning special machinery to the various districts whose members may be anticipating a range reseeding program. The unitiller, a combination plowing and seeding machine, had been used by private ranchers through this arrangement. In the vicinity of Tooele, Utah, where reseeding is extremely popular as a result of the governmental experimental area at Benmore, three of the ranchers interviewed had contracted for the preparation of their seedbed. If reseeding becomes widespread, then it will probably be possible to rent machinery or contract for the reseeding work to be done.

Although a carefully planned reseeding program has been carried out using the latest recommendations in selecting the site and the latest techniques in seeding the area, one factor relatively unaffected by man makes reseeding a risky enterprise. In the arid West water is life. Although a good site selection will modify the effects of a drought, this one factor of climate tends to make artificial range reseeding a gamble.

INVESTMENTS IN RANGE RESEEDING AS CARRIED OUT BY CATTLE RANCHERS IN UTAH

Data on investments in range reseeding as carried out by cattle ranchers in Utah are based on statistics gathered in the field. It was not possible to gather data on all the investments made. When such investments could not be determined by enumeration, it was necessary

to resort to secondary data. These secondary data may not apply directly to Utah ranching conditions. Reasoning was arbitrarily used to adjust results of the secondary data to these conditions. In discussing the various results of the survey, the reasons for and methods used in adjusting secondary data will be given.

Investments have been broken down into six main sections. These are investments resulting from uses of equipment, other equipment, seed, labor, construction and deferment charges. The deferment investment included interest on investment and taxes. As far as could be determined most ranchers did not incur leasing expenses to overcome the loss of grazing due to the deferment. Although the precipitation for the various areas during the reseeding appeared to be below normal, which measure is fairly well correlated with forage production on arid ranges, ranchers tended to double up on their remaining range rather than to lease additional areas. As can be seen by Table 2, which was previously mentioned, the portion reseeded was usually a relatively small amount in proportion to the entire enterprise. Table 3 presents a summary of the factors associated with the various reseeding programs.

Power Equipment Investment Charges

Power investments in reseeding privately-owned cattle ranges in Utah are included in Table 4. The basis for estimating the investment in operating power equipment machines included annual depreciation based on original cost, estimated life and days and hours used annually; annual return on investment, annual upkeep and repair and fuel and lubrication costs per hour (13). To assure a fair estimate it was necessary to adjust the costs from available California farm land operation data to Utah range conditions. Since equipment operation data was not available to

Table 3: General Factors Associated with Investments and Returns From Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Year	Acres Reseeded	Topography	Cultivation 1/	Type of Seed	Pounds of Seed	Years Deferred	Miles of Fence
	Year	Acres		Degree	Type 3/	Pounds	Years	Miles
1	1944	35	Rolling	Mod.	Cr Wh	8.5	4	0
1 A	1945	70	Rolling	Heavy	Cr Wh	8.5	3	2
2	1938	8	Level	Heavy	Cr Wh	5	1	0
4	1943	160	Rolling	Mod.	Cr Wh	4	3	2.5
4 A	1942	160	Level	Light 2/	Cr Wh	4	2	1
5	1940	20	Level	Heavy	Mixt.	12	0	0.25
6	1946	60	Level	Heavy	Mixt.	4	0	2.25
7	1945	480	Level	Mod.	Cr Wh	6	0	1
7 A	1944	120	Level	Heavy	Cr Wh	6	2	0
8	1941	50	Rolling	Heavy	Cr Wh	10	2	1
9	1944	800	Rolling	Mod.	Cr Wh	8	2	0
10	1942	48	Rolling	Heavy	Mixt.	7	1	0
11	1947	200	Hilly	Light	Mixt.	9	1	0.5
12	1946	20	Level	Heavy	Mixt.	8	0	0
13	1943	17	Level	Heavy	Cr Wh	6	0	0
14	1944	1,000	Rolling	Heavy	Cr Wh	4.5	0	4.5
15	1939	160	Level	Heavy	Cr Wh	7	3	0
16	1946	53	Rolling	Heavy	Cr Wh	8	0	0
17	1947	1,450	Rolling	Heavy	Cr Wh	8	1	0
18	1947	115	Rolling	Heavy	Cr Wh	8	1	1.5
19	1938	200	Level	Heavy	Cr Wh	5	1	0

1/ Cultivation degree indicated by slight, moderate or heavy, where slight was broadcasting with no seedbed preparation, moderate was partial preparation including railing and broadcasting or unitillering, and heavy was plowing and drilling.
2/ Area in grain stubble.
3/ "Cr Wh" refers to Crested wheatgrass. "Mixt" refers to seeding with more than one grass species.

Table 4: Power Investments on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Acres	Drawbar Type1/	Hours of Use Per Unit Hours	Average Hours Per Year	Average Total Cost Per Year	Fixed Cost Per Hour	Fuel and Lubrication Per Hour	Total Per Hour	Total Investment	Investment Per Acre
	Acres	Type	Hours	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1	35	T-M	12	312	115.56	.37	.26	.63	7.56	.22
1 A	70	T-M	12	312	115.56	.37	.26	.63	7.56	
		C-M	16	1,616	460.80	.29	.45	.74	11.84	
		Horse	32					.27	8.64	.40
2	8	T-S	44	344	110.29	.32	.17	.49	21.56	2.70
4	160	C-M	80	1,680	460.80	.27	.45	.72	57.60	.36
4 A	160	C-M	24	1,624	460.80	.28	.45	.73	17.52	.11
5	20	T-M	42.4	342.4	115.56	.34	.26	.60	25.44	1.27
6	60	T-L	44	344	115.56	.34	.26	.60	26.40	
		C-M	2/						114.00	2.34
7	480	T-M	153.6	453.6	115.56	.25	.26	.51	78.34	.16
8	50	T-M	24	324	115.56	.36	.26	.62	14.88	.30
9	800	C-L	112	1,712	508.30	.30	.32	.62	69.44	
		Horse	72					.27	19.44	.11
12	20	T-L	24	324	115.56	.36	.26	.62	14.88	.74
13	17	T-S	14	314	110.29	.35	.17	.52	7.28	.43
14	1,000	C-M	424	2,024	460.80	.23	.45	.68	288.32	.29
15	160	Horse	424					.27	114.48	.72
16	53	T-L	56	356	115.56	.32	.26	.58	32.48	.61
17	1,450	C-L	400	1,800	508.30	.28	.32	.60	240.00	.17
18	115	Horse	160					.27	43.20	.38
19	200	Horse	320					.27	86.40	.43
Total	4,858								1,307.26	
Weighted Average										.27
Median										.39

1/ First letter of series refers to either tractor or caterpillar. The second letter indicates size as being small, medium or large.

2/ This machine rented for stated amount.

Utah farming or Intermountain range conditions, the California data appeared to be the most comprehensive and applicable. Since farming operations on California farm lands would probably involve a much lower cost for repairs than would occur on the oftentimes broken terrain and stony soils on Utah ranges, the repair and upkeep cost was arbitrarily doubled. This increase usually amounted to less than $0.01 per hour of operation. Since the reseeding operation comes in addition to ordinary use, hours of operation were increased by the actual hours needed to reseed the areas as stated by the individual ranchers. The annual hours of operation given in the source was first reduced to conform to the results of Hochmuth's studies in the Intermountain area (6). The results of these calculations were costs per hour of operation. These calculations are included in Table 5. The actual investments were calculated by multiplying costs per hour by hours of operations to arrive at the total investment for power equipment uses on the various reseeded ranges.

The total investment in each area was added and averaged, the weighted average of all areas being $0.27 per acre. Investments varied on individual areas from $0.11 to $2.70 per acre. The $2.70 investment occurred on the smallest area of 8 acres. The median investment for the 18 areas surveyed was $0.39 per acre. It was necessary to exclude the three areas for which contract work was done since the contract charge included labor and equipment costs. The contract cost was later included in a summary investment sheet found later in the report (Table 12). This was done by averaging labor and equipment investments on all but contract areas and prorating these latter charges back on a percentage basis.

Horses were used on 5 areas, either partially or wholly, in the preparation of the seedbed and seeding. Basis for calculating horse

Table 5: Basis For Assigning Equipment Investments in Privately-Owned Reseeded Cattle Ranges in Utah

Drawbar	Type	Symbol	Yearly Average Hours	Average Yearly Cost	Repair At 200 Percent	Total Yearly Cost	Fuel and Lubrication	Total Hourly Cost
	Size	Type	Hours	Dollars	Dollars	Dollars	Dollars	Dollars
Tractor	Small	T-S	300	94.99	15.30	110.29	.17	.54
Tractor	Medium	T-M	300	99.51	16.05	115.56	.26	.65
Tractor	Large	T-L	300	99.51	16.05	115.56	.26	.65
Caterpillar	Small	C-S	1,000	212.50	50.00	262.50	.32	.58
Caterpillar	Medium	C-M	1,600	396.80	64.00	460.80	.45	.74
Caterpillar	Large	C-L	1,600	440.30	68.00	508.30	.32	.64

Feed costs for work horses are approximately $161.84 for a 610-hour work-year, or $0.27 per hour.

charges was a calculation based on additional feed charges for horses which ordinarily would be on a maintenance ration. On the basis of a 610-hour work-year (14) feed costs would be $161.84. This amount excludes a small $7.68 charge for pasture, which charge would not occur while feeding horses hay and concentrates on heavy work rations. The calculated flat rate on the basis of additional feed cost was $0.27 per hour worked. In a comparison with the figure quoted, a lower rate was calculated for horse costs in Iowa (5). The calculated cost of $0.112 per hour was based on a 816-hour work-year. Two factors combined to exclude the use of this latter figure. Feed costs would be much lower in the specialized feed-producing area of Iowa and the amount of work per horse probably would be much higher per year than in Utah. Also, the data were based on 1936 prices while the Alabama figures were calculated for 1945.

Other Equipment Investment Charges

Equipment investment charges other than power, as included in Table 6, were also based on California equipment cost data (13). The costs were so small that no attempt was made to adjust them for Utah conditions. Again costs were based on the annual depreciation, interest and upkeep and repair charges. The unitiller machine was not included in the list of machinery. However, since it is a form of plowing attachment, it was assigned the rate for the disk plow. Other reasons for this selection was the similarity in large initial investment and large number of hours used per year. By allowing community use of the unitiller, it is probably used more than the average disk plow in California, which is 40 days per year.

The "Other Equipment" heading included uses of such equipment as levels, broadcasters, rails and wagon broadcasters. When the article was not listed, similar reasoning to the above was used to assign a cost.

Table 6: Equipment Investment Charges Other Than Power on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Acres	Wheatland Plow	Moldboard Plow	Spike-tooth Harrow	Grain Drill	Unitiller	Other	Total Investment	Investment Per Acre
	Acres	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1	35	0	0	0	0	1.80	0	1.80	0.05
1 A	70	4.50	0	0	1.68	0	0.60	6.78	0.10
2	8	0	0.96	1.92	0.56	0	0	3.44	0.43
4	160	0	0	0	2.94	0	0	2.94	0.02
4 A	160	0	0	0	0	12.60	0	12.60	0.08
5	20	0	3.84	0	1.40	0	0	5.24	0.26
6	60	0	0	0	3.36	0	0	3.36	0.06
7	480	0	0	0	0	23.10	0	23.10	0.05
8	50	0	2.88	0	0	0	0.10	2.98	0.06
9	800	0	0	0	0	0	5.60	5.60	0.01
12	20	0	2.40	0	0.56	0	0	2.96	0.15
13	17	0.90	0	0	0.70	0	0	1.60	0.09
14	1,000	13.12	0	0	3.24	0	2.80	19.16	0.02
15	160	0	38.40	0	13.44	0	0	51.84	0.32
16	53	6.00	0	0	2.24	0	0	8.24	0.16
17	1,450	60.00	0	0	56.00	0	0	116.00	0.08
18	115	0	6.40	0	11.20	0	0	17.60	0.15
19	200	0	6.40	0	11.20	0	0	17.60	0.09
Total	4,858							302.84	
Weighted Average									0.06
Median									0.06

The average weighted investment per acre for use of other equipment than power was $0.06 for 18 areas on 4858 acres. The median investment was $0.09. Investments ranged from a minimum of $0.01 per acre on 800 acres to $0.43 per acre on 8 acres. The degree of preparation of seedbed and seeding was usually intense, including plowing, harrowing and drilling or unitillering, causing a wide use of equipment.

Seed Investments

Short (23) has stated that the cost of seed varies with the supply and demand from year to year, the species used and the rate of sowing. Less seed is used in drilling than in broadcasting. In his study Short recommended 3 to 5 pounds of crested wheatgrass seed per acre if drilled and 4 to 6 pounds per acre when broadcasted.

Cattle ranchers in Utah sowed from 4 to 12 pounds of grass seed per acre on reseeded ranges. The cost per pound ranged from $0.10 to $1.75. The heaviest seeding was made on a 20-acre area using a mixture of two grasses, a clover and alfalfa. The smallest cost per pound occurred when the rancher himself raised the seed. His estimate of cost was based on comparing costs of raising Crested wheatgrass seed with dryland wheat. The seed with the greatest cost per pound was a mixture of three perennial grasses, two clovers and annual rye. It was necessary to seed this area twice due to the differences in sizes of the seeds. Crested wheatgrass was used exclusively in 75 percent of the cases. In the remaining 24 percent of the cases it was included all but once in the mixtures.

The weighted average seed investment on 5226 acres as indicated in Table 7 was $1.18 per acre. Investments varied from $0.54 per acre to $7.00. The median charge was $1.27 per acre.

Table 7: Investments in Seed for Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Acres	Type of Seed	Pounds of Seed Per Acre	Year	Cost Per Pound	Seed Investment Per Acre	Total Investment
	Acres	Type	Pounds	Year	Dollars	Dollars	Dollars
1	35	Cr Wh	8.5	1944	0.15	1.275	44.62
1 A	70	Cr Wh	8.5	1945	0.15	1.275	89.25
2	8	Cr Wh	5	1938	0.22	1.100	8.80
4	160	Cr Wh	4	1943	0.25	1.000	160.00
4 A	160	Cr Wh	4	1942	0.25	1.000	160.00
5	20	Mixt.	12	1940	0.25	3.000	60.00
6	60	Mixt.	4	1946	1.75	7.000	420.00
7	480	Cr Wh	6	1945	0.10	0.600	288.00
7 A	120	Cr Wh	6	1944	0.10	0.600	72.00
8	50	Cr Wh	10	1944	0.27	2.700	135.00
9	800	Cr Wh	8	1944	0.17	1.360	1,088.00
10	48	Mixt.	7	1942	0.15	1.050	50.40
11	200	Mixt.	9	1947	0.20	1.800	360.00
12	20	Mixt.	8	1946	0.20	1.600	32.00
13	17	Cr Wh	6	1943	0.17	1.020	17.34
14	1,000	Cr Wh	4.5	1944	0.12	0.540	540.00
15	160	Cr Wh	7	1939	0.30	2.100	336.00
16	53	Cr Wh	8	1946	0.27	2.160	114.48
17	1,450	Cr Wh	8	1947	0.14	1.120	1,624.00
18	115	Cr Wh	8	1947	0.25	2.000	230.00
19	200	Cr Wh	5	1938	0.36	1.800	360.00
Total	5,226						6,189.89
Weighted Average						1.18	
Median						1.27	

Labor Investment Charges

Labor investment charges were based on the number of 8-hour man-days that were actually spent on the reseeding project and the wage rate per day without board paid in the Mountain division during the particular year reseeded (1). All labor was assigned an equal rate for any given year despite the differences in position and skill of the principals. As indicated in Table 8, investments in labor varied from $0.08 per acre to $1.57, with $0.27 being the weighted average on 4858 acres. The median investment was $0.44 per acre. The low investment charge came as a result of the area being in grain stubble prior to reseeding. This allowed a direct seeding into the area with no prior seedbed treatment. As discussed under the equipment investment data, the three contract areas were later prorated back to labor and equipment charges, resulting in the slightly different figures in the summary table (Table 12).

Construction Investment Charges

Construction investment charges are indicated in Table 9. For the most part these investments resulted from fence constructions. In the two cases of miscellaneous construction costs that occurred, either water was developed or corrals built.

Fencing has been considered necessary on most newly seeded areas. A considerable amount of fencing has been the rule on western cattle ranges (6). In some cases, reseeded areas were adjacent to fences already constructed, meaning at least one side of the area was already fenced. In other cases it was possible to reseed areas already under fence. This helped to decrease the investment charged to reseeding because, as the areas decreased in size, the greater proportion of fence to area in the smaller areas caused the investments in fences per acre to be extremely high.

Table 8: Labor Investment Charges on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Number Acres Reseeded	Year	Man Days Labor	Rate Per Day	Total Labor Investment	Investment Per Acre
	Acres	Year	Eight Hour Days	Dollars	Dollars	Dollars
1	35	1944	3.00	5.44	16.32	0.47
1 A	70	1945	8.25	5.87	48.43	0.69
2	8	1938	5.50	2.29	12.59	1.57
4	160	1943	2.62 1/	4.77	12.50	0.08
4 A	160	1942	10.50	3.65	38.32	0.24
5	20	1940	5.33	2.50	13.32	0.67
6	60	1946	12.00	6.07	72.84	1.21
7	480	1945	19.20	5.87	112.70	0.23
8	50	1941	5.00	2.82	14.10	0.28
9	800	1944	37.00	5.44	201.28	0.25
12	20	1946	2.90	6.07	17.60	0.88
13	17	1943	1.47	4.77	7.01	0.41
14	1,000	1944	20.60	5.44	112.06	0.11
15	160	1939	52.50	2.27	119.18	0.74
16	53	1946	12.00	6.07	72.84	1.37
17	1,450	1947	50.00	7.09	354.50	0.24
18	115	1947	10.00	7.09	70.90	0.62
19	200	1938	10.00	2.29	22.90	0.11
Total	4,858				1,319.39	
Weighted Average						0.27
Median						0.44

1/ Area in grain stubble prior to reseeding.

Table 9: Investments in Constructions on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Number of Acres Reseeded	Miles of Fence	Cost per Mile	Total Fence Invest.	Misc. Construction Cost 1/	Total Investment	Investment per Acre
	Acres	Miles	Dollars	Dollars	Dollars	Dollars	Dollars
1	35	0	0	0	0	0	0
1 A	70	2.00	527	1,054	0	1,054	15.06
2	8	0	0	0	0	0	0
4	160	2.50	500	1,250	0	1,250	7.81
4 A	160	1.00	550	550	0	550	3.44
5	20	0.25	300	75	0	75	3.75
6	60	2.25	500	1,125	100	1,225	20.42
7	480	1.00	488	488	0	488	1.02
7 A	120	0	0	0	0	0	0
8	50	1.00	550	550	0	550	1.10
9	800	0	0	0	0	0	0
10	48	0	0	0	0	0	0
11	200	0.50	640	320	0	320	1.60
12	20	0	0	0	0	0	0
13	17	0	0	0	0	0	0
14	1,000	4.50	480	2,160	0	2,160	2.16
15	160	0	0	0	0	0	0
16	53	0	0	0	600	600	11.13
17	1,450	0	0	0	0	0	0
18	115	1.50	500	750	0	750	6.52
19	200	0	0	0	0	0	0
Total	5,226					9,022	
Weighted Average							1.73
Median							1.02

1/ Includes water development, construction of corrals and moving of fences, buildings, etc.

Barbed wire fences predominate on cattle ranges in Utah. Also, four-strand fences with posts a rod apart were generally the rule. On fences of this type Kelley in 1940 (12) found the average construction charge to be $216 per mile. Investments in the materials and labor for fences has evidently been correlated rather closely with farming costs. It was found that fencing became so expensive during the war years and immediately after that costs to Utah ranchers for barbed wire fences more than doubled. When materials were available, it was necessary to make expenditures with extreme care. In some cases, on smaller areas, fencing costs made up an extremely large share of the total reseeding investment.

Investments in fences were calculated by determining the miles of fence constructed in conjunction with the reseeding program and multiplying this amount by the ranchers' estimates of costs per mile. About one-half of the ranchers, or 11 ranchers, did not attempt fencing. Of this number 8 stated the area was already fenced. Another area was so far from water that trespassing was not expected. The two remaining ranchers who did not fence complained of trespassing.

No charges were made against the reseeding projects on areas where constructions already existed. Besides the difficulty of determining the amounts and values of fencing having an appreciable effect on the reseeding project, it was not thought possible to estimate a division of the charge based on benefits between the reseeding project and the prior use for which the fences were constructed. However, since a rather direct relationship exists between charge per acre for constructions and size of area reseeded, as indicated in Table 9, should some charge estimate be desired it would probably be possible to make an estimate, assuming all benefits and charges would accrue to the reseeded area.

The weighted average investment per acre for constructions was $1.73 on 5226 acres. Investment charges ranged from no expense to an extremely high expense of $20.42 per acre. This last charge was experienced on a 60-acre tract on which 2¼ miles of fence and two corrals were constructed. The area, as indicated by native vegetation, was moist bottomland having a very high potential grazing capacity, which may have justified the high seed and construction charges.

Investments per mile of fence varied from $300 in 1940 to $640 in 1947. All fencing was built between these two periods.

Deferment Charges

Deferment charges included interest on investment and tax costs. Interest on investment, as indicated in Table 10, was calculated by assigning a flat $5.00 value per acre reseeded and adding to this amount the seed bed, seeding and construction charges to find the base value. Since leasing costs did not occur, no additional charge for this item were included. The rates for interest and base range land values were taken from the studies of the Intermountain cattle ranch by Hochmuth (6). The yearly interest amount, determined by multiplying the rate times the accumulated land value, was multiplied by the number of years deferred to find the total interest on investment during the deferment.

The weighted rate per acre was $0.44 on 5226 acres. Rates varied from no cost on areas with no deferment, to $3.04 on an area deferred for three years. The median charge was $0.43 per acre.

Tax charges are included in Table 11. The tax rates were based on the same source and were calculated by using the same procedure as the determination of interest on investment. Tax charges varied from no charge on areas which were not deferred to $0.78 on an area deferred for three years. The weighted average and median charges were $0.11 per acre.

Table 10: Interest on Investment on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Number of Acres	Value of Land 1/	Reseeding Investment 2/	Total Value Land	Year Reseeded	Number Years Deferred	Interest Rate 3/	Interest Per Year	Total Interest	Interest Per Acre
	Acres	Dollars	Dollars	Dollars	Year	Years	Percent	Dollars	Dollars	Dollars
1	35	175.00	70.30	245.30	1944	4	4.7	11.53	46.12	1.32
1 A	70	350.00	1,226.50	1,576.50	1945	3	4.5	70.94	212.82	3.04
2	8	40.00	46.39	86.39	1938	1	5.0	4.32	4.32	0.54
4	160	800.00	1,483.04	2,283.04	1943	3	4.6	105.02	315.06	1.97
4 A	160	800.00	778.44	1,578.44	1942	2	4.7	74.19	148.38	0.93
5	20	100.00	179.00	279.00	1940	0	4.8	13.39	0	0
6	60	300.00	1,861.60	2,161.60	1946	0	4.3	92.95	0	0
7	480	2,400.00	990.14	3,390.14	1945	0	4.5	152.56	0	0
7 A	120	600.00	552.00	1,152.00	1944	2	4.7	54.14	108.28	0.90
8	50	250.00	716.96	966.96	1941	2	4.7	45.45	90.90	1.82
9	800	4,000.00	1,383.76	5,383.76	1944	2	4.7	253.04	506.08	0.63
10	48	240.00	194.40	434.40	1942	1	4.7	20.42	20.42	0.43
11	200	1,000.00	755.00	1,755.00	1947	1	4.3	75.46	75.46	0.38
12	20	100.00	67.44	167.44	1946	0	4.3	7.20	0	0
13	17	85.00	33.23	118.23	1943	0	4.6	5.44	0	0
14	1,000	5,000.00	3,119.54	8,119.54	1944	0	4.7	381.62	0	0
15	160	800.00	621.50	1,421.50	1939	3	4.9	69.65	208.95	1.31
16	53	265.00	828.04	1,093.04	1946	0	4.3	47.00	0	0
17	1,450	7,250.00	2,334.50	9,584.50	1947	1	4.3	412.13	412.13	0.28
18	115	575.00	1,111.70	1,686.70	1947	1	4.3	72.53	72.53	0.63
19	200	1,000.00	486.90	1,486.90	1938	1	5.0	74.34	74.34	0.37
Total	5,226	26,130.00	18,840.38	44,970.38					2,295.79	
Weighted Average										0.44
Median										0.43

1/ Basic land value estimated at $5 per acre prior to reseeding. Based on calculations in Study of Commercial Family-Operated Intermountain Cattle Ranches.
2/ Includes all costs except Investment and Tax costs.
3/ Same as footnote 1.

Table 11: Tax Charges on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Number Acres	Year Reseeded	Years Deferred	Tax Rate 1/	Value 2/	Tax Per Year	Total Tax	Tax Per Acre
	Acres	Year	Years	Dollars	Dollars	Dollars	Dollars	Dollars
1	35	1944	4	0.98	245.30	2.40	9.60	0.27
1 A	70	1945	3	1.16	1,576.50	18.29	54.69	0.78
2	8	1938	1	1.44	86.39	1.24	1.24	0.16
4	160	1943	3	1.05	2,283.04	23.97	71.91	0.45
4 A	160	1942	2	1.18	1,578.44	18.63	37.26	0.23
5	20	1940	0	1.46	279.00	4.07	0	0
6	60	1946	0	1.18	2,161.60	25.51	0	0
7	480	1945	0	1.16	3,390.14	39.33	0	0
7 A	120	1944	2	0.98	1,152.00	11.29	22.58	0.19
8	50	1941	2	1.36	966.96	13.15	26.30	0.53
9	800	1944	2	0.98	5,383.76	52.76	105.52	0.13
10	48	1942	1	1.18	434.40	5.13	5.13	0.11
11	200	1947	1	1.20	1,755.00	21.06	21.06	0.11
12	20	1946	0	1.18	167.44	1.98	0	0
13	17	1943	0	1.05	118.23	1.24	0	0
14	1,000	1944	0	0.98	8,119.54	79.57	0	0
15	160	1939	3	1.47	1,412.50	20.76	62.28	0.39
16	53	1946	0	1.18	1,093.04	12.90	0	0
17	1,450	1947	1	1.20	9,584.50	115.01	115.01	0.08
18	115	1947	1	1.20	1,686.70	20.24	20.24	0.18
19	200	1938	1	1.44	1,486.90	21.41	21.41	0.11
Total	5,226						574.23	
Weighted Average								0.11
Median								0.11

1/ Tax rate in Utah per $100 of assessed valuation.
2/ Value includes all costs of reseeding except interest on investment and taxes.

Summary of Investments in Artificial Reseeding

The Summary of Investments Table (Table 12) totals all of the above charges. By including the prorated contract charges, labor and equipment investments vary slightly from that of the basic tables. Average weighted investment charges are given for each of the major investment items and are totaled to determine the total investment and the investments per acres on the various areas. In this latter respect the total investment per acre varied from $1.95 to $31.03. The weighted average investment per acre was $4.15. The median investment was $5.58 per acre. For future use it would probably be realistic to adjust this investment to include possibility of failure. Assuming a complete failure it will be necessary to again seed the area. This would cause at least a partial duplication of the seeding investment, to include labor, seed, equipment and deferment charges. An accumulation of relative charges for each of the above would amount to approximately 40 percent. To attain a successful stand after a complete failure, a reseeding investment charge of $5.18 per acre would be necessary when based on the particular price levels used in this study.

RETURNS FROM GRAZING RESEEDED CATTLE RANGES IN UTAH

It is possible that returns from reseeded ranges may be due in part to the effects of the recovery of native grasses during the deferment. However, a complete plowing of the site plus the short deferment period which occurred in many cases allowed a comparison of gains between areas where native vegetation was and was not present. In two of the 12 areas studied the operation was not intensive enough to eliminate all native vegetation. In both areas (Ranchers 9 and 11) the results were below average both in gain in capacities and average weight gains per acre.

The precipitation for Utah has varied widely during the reseeding

Table 12: Summary of Investments in Privately-owned Reseeded Cattle Ranges in Utah

Rancher	Number Acres Reseeded	Year Reseeded	Number Years Deferred	Seeding Investments						Deferment Investment			Total Investment	Investment per Acre
				Seed Investment	Labor Investment	Construction Investments	Power Equipment Investment	Other Equipment Investment	Total Investment	Interest on Investment	Tax Investment	Total Investment		
	Acres	Year	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1	35	1944	4	44.62	16.32	0	7.56	1.80	70.30	46.12	9.60	55.72	126.02	3.60
1 A	70	1945	3	89.25	48.43	1,054.00	28.04	6.78	1,226.50	212.82	54.69	267.51	1,494.01	21.34
2	8	1938	1	8.80	12.59	0	21.56	3.44	46.39	4.32	1.24	5.56	51.95	6.49
4	160	1943	3	160.00	12.50	1,250.00	57.60	2.94	1,483.04	315.06	71.91	386.97	1,870.01	11.69
4 A	160	1942	2	160.00	38.32	550.00	17.52	12.60	778.44	148.38	37.26	185.64	964.08	6.03
5	20	1940	0	60.00	13.32	75.00	25.44	5.24	179.00	0	0	0	179.00	8.95
6	60	1946	0	420.00	72.84	1,225.00	140.40	3.36	1,861.60	0	0	0	1,861.60	31.03
7	480	1945	0	288.00	112.70	488.00	78.34	23.10	990.14	0	0	0	990.14	2.06
7 A 1/	120	1944	2	72.00	218.71	0	211.08	50.21	552.00	108.28	22.58	130.86	682.86	5.69
8	50	1941	2	135.00	14.10	550.00	14.88	2.98	716.96	90.90	26.30	117.20	834.16	16.68
9	800	1944	2	1,088.00	201.28	0	88.88	5.60	1,383.76	506.08	105.52	611.60	1,995.36	2.49
10 1/	48	1942	1	50.40	65.62	0	63.32	15.06	194.40	20.42	5.13	25.55	219.95	4.58
11 1/	200	1947	1	360.00	34.17	320.00	32.98	7.85	755.00	75.46	21.06	96.52	851.52	4.26
12	20	1946	0	32.00	17.60	0	14.88	2.96	67.44	0	0	0	67.44	3.37
13	17	1943	0	17.34	7.01	0	7.28	1.60	33.23	0	0	0	33.23	1.95
14	1,000	1944	0	540.00	112.06	2,160.00	288.32	19.16	3,119.54	0	0	0	3,119.54	3.12
15	160	1939	3	336.00	119.18	0	114.48	51.84	621.50	208.95	62.28	271.23	892.23	5.58
16	53	1946	0	114.48	72.84	600.00	32.48	8.24	828.04	0	0	0	828.04	15.62
17	1,450	1947	1	1,624.00	354.50	0	240.00	116.00	2,334.50	412.13	115.01	527.14	2,861.64	1.97
18	115	1947	1	230.00	70.90	750.00	43.20	17.60	1,111.70	72.53	20.24	92.77	1,204.47	10.47
19	200	1938	1	360.00	22.90	0	86.40	17.60	486.90	74.34	21.41	95.75	582.65	2.91
Total	5,226			6,189.89	1,637.89	9,022.00	1,614.64	375.96	18,840.38	2,295.79	574.23	2,870.02	21,710.40	
Investment per Acre				1.18	0.31	1.73	0.31	0.07	3.60	0.44	0.11	0.55		4.15
Percent of Total Investment				28.4	7.5	41.7	7.4	1.7	86.7	10.6	2.7	13.3		100.0

1/ Contract charges proportioned back to labor and equipment on the basis of the percentages derived from all other data.

operation. As indicated in Figure 1, the level of precipitation has been generally above the long-time average since 1934. It is possible to theorize that a portion of the gains may have been due to favorable precipitation after reseeding and unfavorable precipitation before reseeding. Without a doubt the favorable precipitation during the last decade probably allowed results which were above average. It was not possible to isolate this factor so as to establish average gains during periods of average precipitation.

Grazing Capacity Gains

Gains in grazing capacities were determined by calculating the average estimated stocking rate before and after reseeding. An average before stocking rate resulted from estimates of ranchers of the number, ages, and length of period the animals were on the reseeded area during an average year. The capacities were calculated by reducing the varied-aged animals to a common animal unit using the conversion ratios which follows. Also, the number of animals were adjusted according to the estimates of the various ranchers as to what constituted full use.

Type of Animal	Animal Unit Factor
Cow	1.0
2-Year-Old Steer or Heifer	1.0
1-Year-Old Steer or Heifer	0.7
Bull	1.25
Calf	0.4

Animal units were multiplied by the number of months on the areas to find the total animal unit months (hereinafter referred to as AUM's) which the area supported before reseeding.

The writer attempted to trace the history of grazing use since reseeding. Although the date when the areas were first grazed could be remembered, most ranchers were unable to recall exact stocking figures and tended

instead to give a lump figure representing a more or less permanent average capacity. These "after reseeding" capacities were reduced to AUM's similar to "before reseeding" capacities. By subtracting capacities "before" from "after" it was possible to calculate net grazing capacity gains. It is recognized that these estimates might vary widely from the actual capacities had a detailed grazing record been kept for the limited reseeding area. The factors affecting gains of beef animals on range pastures are so varied and have relative effects which are even yet not fully understood. Exact measures of capacity and gain, although highly accurate for given places under given conditions, can not be applied to extensive areas without making assumptions. These assumptions, which are subjective, may or may not reduce the accuracy of limited exact measures until they are comparable to an original extensive estimate.

The gains represented in Table 13 ranged from a minus 0.90 and minus 0.64 to a positive 1.096 AUM's per acre. The average weighted gain was 0.304 AUM's per acre.

Expressed in slightly different terms, the average weighted capacity on the 2616 acres before reseeding was 8.73 acres per AUM. After reseeding only 2.39 acres were required to support one AUM. This represented a grazing gain in capacity of 365 percent. This figure approximates the results (433%) of Price's study (19) of Crested wheatgrass at lower elevations on oak-brush range in Utah and is considerably below the gains as reported on a sagebrush area in the Fishlake National Forest in central Utah (16).

Weight Gains

Besides the gain in capacities from reseeded ranges it was possible to estimate the weight gains on animals using the area after reseeding.

Table 13: Reported Gains or Losses in Grazing Capacities on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Number of Acres Reseeded	Year Reseeded	Before Reseeding			After Reseeding			Gain in A.U.M.'s	
			A.U.'s	Months	A.U.M.'s	A.U.'s	Months	A.U.M.'s	Total	Per Acre
	Acres	Year	Units	Months	A.U.M.'s	Units	Months	A.U.M.'s	A.U.M.'s	A.U.M.'s
2	8	1938	0.00	0.00	0.00	8.00	0.67	5.36	5.36	0.670
5	20	1940	3.75	3.00	11.25	14.00	1.50	21.00	9.75	0.488
6	60	1946	5.30	3.00	15.90	7.10	3.00	21.30	5.40	0.090
8	50	1941	13.00	1.00	13.00	66.00	1.00	66.00	53.00	1.060
9	800	1944	14.00	1.50	21.00	142.00	1.50	213.00	192.00	0.240
10	48	1942	5.00	3.33	16.65	4.00	3.33	13.32	-3.33	-0.069
11	200	1947	6.00	2.00	12.00	12.00	2.00	24.00	12.00	0.060
13	17	1943	6.00	0.50	3.00	24.00	0.50	12.00	9.00	0.529
14	1,000	1944	30.00	1.00	30.00	216.00	2.00	432.00	402.00	0.402
15	160	1939	8.00	12.00	96.00	60.00	3.00	180.00	84.00	0.525
16	53	1946	41.00	0.75	30.75	26.00	1.00	26.00	-4.75	-0.090
19	200	1938	25.00	2.00	50.00	41.00	2.00	82.00	32.00	0.160
Total	2,616		157.05		299.55	620.10		1,095.98	796.43	
Weighted Average					0.115			0.419	0.304	
Acres Per A.U.M.					8.73			2.39	6.34	

The field calculations were derived essentially the same way as were capacity estimates, that is, from the estimates of ranchers unsupported by physical weight measures. The variation from the above calculation method consisted of including only calves, yearlings and two-year-olds in the computation. Mature cows and bulls were expected to gain from the better ranges but losses would probably accrue during the breeding function. Also, the breeding herd animals would not be sold except as they became old or defective in the breeding function.

Gains were estimated by ranchers either as a lump sum for the period or by days or months. The answers were reduced to monthly gains. By multiplying number of gaining animals by gains per month by months on the area it was possible to arrive at total weight gains before and after reseeding.

As indicated in Table 14, average net weight gains were 9.49 pounds per acre. Weighted gains before reseeding averaged 3.32 pounds per acre and after reseeding 12.81 pounds. The areas were grazed during all seasons but it was found that most areas were grazed either in the spring or fall. In most cases no change was made in season of grazing between the "before" and "after" reseeding periods.

ANALYSIS

Physical Factors

There were such a wide variety of unmeasurable factors affecting the degree of success of the reseeding projects that, in view of the scope of this study, no detailed analyses of these factors were possible. An attempt was made to correlate precipitation with yield by comparing the precipitation during the reseeding and the year prior to reseeding with the yield (Table 15). Also, the critical period precipitation (May-September) was

Table 14: Reported Net Animal Weight Gains Obtained from Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Acres	Before Reseeding				After Reseeding				Net Gain in Pounds	
		Number of Animals	Gain per Month	Number of Months	Total	Number of Animals	Gain per Month	Number of Months	Total	Total	Per Acre
	Acres	Animals	Pounds	Months	Pounds	Animals	Pounds	Months	Pounds	Pounds	Pounds
2	8	0	0	0	0	0	0	0	0	0	0
5	20	2	33.0	3.00	198	10	33.0	1.50	495	297	10.48
6	60	3	66.0	3.00	594	10	66.0	3.00	1,980	1,386	23.10
8	50	8	7.5	1.00	60	40	15.0	1.00	600	540	10.80
9	800	8	30.0	1.50	360	80	45.0	1.50	5,400	5,040	6.30
10	48	3	30.0	3.33	300	2	45.0	3.33	300	0	0
11	200	8	37.5	2.00	600	15	52.5	2.00	1,575	975	4.88
13	17	3	15.0	0.50	22	10	30.0	0.50	150	128	7.53
14	1,000	20	30.0	1.00	600	140	45.0	2.00	12,600	12,000	12.00
15	160	12	36.7	12.00	5,280	50	55.0	3.00	8,250	2,970	18.56
16	53	24	8.0	0.75	144	16	45.0	1.00	720	576	10.87
19	200	9	30.0	2.00	540	16	45.0	2.00	1,440	900	4.50
Total	2,616				8,698				33,510	24,812	
Average	218				3.32				12.81		9.49

Table 15: Factors Associated with Yields on Privately-Owned Reseeded Cattle Ranges in Utah

Rancher	Acres Reseeded	Year Reseeded	Season Reseeded	Years Deferred	Type of Seed	Precipitation During Reseeding 1/		Precipitation Before Reseeding 2/		Critical Period Precipitation 3/		Coef./ VSY	Net Pounds Gain Per Acre	Net A.U.M.'s Gain Per Acre
	Acres	Year	Season	Years	Species 4/	In.	Index	In.	Index	In.	Index	Coef.	Pounds	A.U.M.'s
2	8	1938	Fall	1	Cr Wh	12.87	77	17.37	103	2.57	61	2.34	0	0.670
5	20	1940	Spring	0	Mixt.	14.02	98	12.34	86	.69	18	2.29	10.48	0.488
6	60	1946	Spring	0	Mixt.	5.22	57	7.10	77	1.30	58	5.07	23.10	0.090
8	50	1941	Fall	2	Cr Wh	14.40	100	15.63	109	2.38	64	2.29	10.80	1.060
9	800	1944	Fall	2	Cr Wh	7.10	77	6.43	70	2.21	99	5.07	6.30	0.240
10	48	1942	Fall	1	Mixt.	14.54	87	19.66	118	4.12	98	2.34	0	-0.069
11	200	1947	Spring	1	Mixt.	19.87	118	18.93	112	4.76	112	2.43	4.88	0.060
13	17	1943	Spring	0	Cr Wh	14.54	87	19.66	118	4.12	98	2.34	7.53	0.529
14	1,000	1944	Fall	0	Cr Wh	15.72	127	15.14	123	6.04	165	3.41	12.00	0.402
15	160	1939	Fall	3	Cr Wh	14.02	98	12.34	86	0.69	18	2.29	18.56	0.525
16	53	1946	Fall	0	Cr Wh	12.22	85	13.66	95	7.79	165	4.28	10.87	-0.090
19	200	1938	Fall	1	Cr Wh	12.87	77	17.37	103	2.57	61	2.34	4.50	0.160
Average				1			91		100		85		9.49	0.304

1/ Precipitation is total of 12 months starting with October and ending after September. In cases of fall seeding, the following plant year precipitation is included. Indices are based on the long-time totals of weather stations adjoining the reseeded areas.

2/ Precipitation before is the period ending in September of year before reseeding.

3/ Critical period is the first May 1st through August 30th period following reseeding. Indices are based on the long-time critical period totals of weather stations adjoining the reseeded areas.

4/ Cr Wh refers to Crested wheatgrass. Mixt. refers to seeding with more than one grass species.

included. A Coefficient of Variability Sequence as explained previously was included to show the length of the cycle of precipitation and indirectly the severeness of drought in the individual areas.

One of the few consistent variables that could be associated with the three areas having at least a partial failure was the season of planting. It was not possible, however, to rule out chance in attempting to associate failures with fall plantings.

Another variable which was common to the partial or entire reseeding failures of Ranchers 2, 10 and 15 was the subnormal precipitation that occurred during the years reseeded. Using the long-time averages as a base, the average index for these areas was 83 as compared with the overall average of 91. Indices of precipitation during the critical period and for the year preceeding reseeding for the three areas were above the average and above normal.

Investments

On the areas surveyed, construction charges have the most weight (Table 12). On a total investment basis, construction charges made up 42 percent of the total investment per acre. Seed investment charges were also high, being 28 percent of the total. These two items combined made up 70 percent of the total investment. Minor charges included equipment, labor and tax charges, with the interest on investment item being intermediate.

Net Returns

In discussing the subject of investments in and returns from range reseeding one of the first questions usually asked is, "Does it pay?" Two approaches can be made to estimate the net returns of the reseeding operation on the basis of the available data. By following the procedure as

outlined by Stoddart and Smith (27) it was possible to measure the annual net return which accrued because of the reseeding operation after the annual value of capital expended on the project is deducted.

With an average investment of $4.15 per acre, an investment of $518.75 would be necessary to reseed 125 acres. The return to be expected when the interest rate on money is 4.3 percent was $22.31. Allocating this against a net increased capacity of 38 cow months (0.304 AUM's net gain per acre) placed a value of $0.59 on each cow month of additional grazing. The actual value of a cow month of grazing in Utah has varied with place, season and time. Two levels of values were assumed. With a low level of $0.50 per cow month of grazing, a net loss of $0.09 per cow month was realized. However, in addition to the increased capacity, from the statistics on returns, the area may be expected to produce 1186 additional pounds of beef (9.49 net pounds per acre). Since the long-time average price per hundredweight for Utah beef is $7.76 (6), then an additional $92.05 accrued as net return. With the low level of cow month value causing a loss of $3.42 for 38 cow months, the total net annual gain on 125 reseeded acres was $88.63, or $0.71 per reseeded acre.

Assuming a higher leasing value level of $1.00 per cow month, the net return would be $0.41 per cow month. A total net annual gain as calculated above when using this latter level would be $107.63, or $0.86 per reseeded acre.

It is probable that the benefits from range reseeding may decrease over a period of years until these benefits are nil. It is not possible to estimate the length of these benefits since results from this phase of range reseeding investigations are not yet available.

Net Returns by Budgeting

By averaging long-time costs and returns on Hochmuth's study (6) it was possible to calculate the net return on the average family-operated Intermountain cattle ranch. By inserting the average Utah reseeding operation into the budgets of this ranch, and by carrying these budgets through several years unchanged except by effects of the reseeding operation, any variation in net returns will be due to the reseeding operation alone. Assuming the benefits from the reseeding operation will extend over a 20-year period, it will be necessary to make an annual payment on capital equivalent to 5 percent of the original investment. In addition to this amount a charge for use of the outstanding capital investment should be added to the annual payment. The going long-term interest rate of 4.3 percent was used (6). The results of these calculations are summarized in Table 16.

Before Reseeding

This period represents the average ranch enterprise as it has existed during the period 1930 through 1946. This period can be assumed to be the base period.

During Reseeding

During this period 125 acres of range was reseeded. Whether the area was reseeded during the fall of the previous year or during the current spring, the first annual charge for the project was included in this budget. In anticipation of an increased capacity, one 2-year-old heifer was held back from market. Income from crops was slightly lower to carry this extra animal through the winter. Cash expenditures were higher due to the necessity of renting additional range to compensate for loss of grazing on the reseeded area.

Table 16: Effects of Reseeding on Budgets of the Intermountain Family-Operated Area Type Cattle Ranch

Item	Before Reseeding (1942)	During Reseeding (1943)	1st Year Grazed (1944)	2nd Year Grazed (1945)	3rd Year Grazed (1946)
			(Dollars)		
Income from livestock and livestock products	4,667.66	4,594.02	4,705.22	4,742.78	4,856.54
Income from crops	211.21	200.40	195.31	184.81	184.81
Government payments	146.37	144.71	147.01	147.83	151.24
Gross cash income	5,025.24	4,938.25	5,047.54	5,075.42	5,192.59
Cash expenses	1,652.90	1,670.43	1,663.41	1,652.54	1,652.57
Reseeding investment Cost	0.00	48.24	47.13	46.02	44.90
Net cash income	3,372.34	3,219.58	3,337.00	3,376.86	3,495.12
Non-cash farm expenses	1,291.96	1,294.44	1,297.60	1,303.04	1,309.52
Labor income, plus interest on investment in land	2,080.38	1,925.14	2,039.40	2,073.82	2,185.60
Variation from base period	0.00	-155.24	-40.98	-6.56	105.22

1st Year Grazed

The herd was increased by the new cow and her calf for this period. Cash expenses were increased slightly from the base period to pay for the slightly larger herd. Since non-cash farm expenses were a set percent of the values of buildings, livestock and machinery, this item, which represents depreciation and interest other than on the reseeded area, also increased slightly. It was still necessary to rent additional range. However, since the reseeded area had been seeded for a year and a half (assuming the more popular fall seeding) a light grazing was made for the first time on the reseeded area.

2nd Year Grazed

A full use of the reseeded area was possible during this period. The 2-year-old animals which went to market this year have had the benefit of two years on the improved reseeded range, allowing an increased market weight. The herd had been increased by a cow, calf and a yearling over the base period.

3rd Year Grazed

This period represented a newly normal condition after reseeding. The herd was built up to take advantage of the additional grazing. The herd had a net increase of a cow, calf, yearling and 2-year-old. The long 2-year-old heifer, which was the additional calf born the year of the reseeding operation, was sold during this period. All long 2-year-olds had an increased weight gain over all previous shipments due to the benefit of being two plus years on the improved reseeded area.

SUMMARY

The depletion of many western range areas by livestock has caused a lowered carrying capacity. A considerable amount of research has been

accomplished in attempting to provide a background of experience for the revegetation of the range by artificial means. Research has been aimed at answering the questions of where, what, when and how to reseed, and after the seeding, how to manage the area. The factors to consider in answering these questions have been dealt with in this study on the basis of the latest research findings.

Utah cattle ranchers have been concerned with the reseeding program for a considerable number of years. By using experimental areas, governmental research agencies have demonstrated the desirability of reseeding selected areas. In adopting reseeding programs the private ranch operator is interested in one further question on reseeding -- "how much?" Governmental reports have attempted to answer this question in part on the basis of their experimental reseeding programs which are not directly applicable to reseeding on privately-owned spring-fall areas. It is these areas which are the most critical and on which the reseeding practices have been concentrated.

The study was designed to describe the latest approved techniques of range reseeding in Utah and the average investment necessary for the applications of some of these techniques as carried out by the individual operators. Measures of investment charges and returns were attempted to determine the economic feasibility of the various programs. Through a survey conducted during the summer of 1948 it was possible to contact over 50 ranchers throughout the state and interview them concerning their programs.

From this survey for the period 1938 through 1947, 21 completed records representing 5226 acres were summarized and analyzed. It was found that the investment in the average area reseeded was $4.15 per acre. Investments were broken down into 6 main sections: power equipment, other equipment,

seed, labor, construction and deferment. Construction and seed investments together accounted for 70 percent of the total investment. Interest on the investment was of lesser importance while equipment, labor and tax charges were minor in comparison to the above major costs.

The effects of a complete failure on the initial investment was considered. The duplication caused by a second seeding increased the investment estimate to $5.18 per acre.

Conditions were such that only 12 areas reported returns from grazing that could be compared in any way with the "before reseeding" period. On the 12 areas, comprising 2616 acres, the average reseeded acre returned a net yield of 0.304 AUM's plus 9.49 pounds of beef per acre. The average range would provide a cow month on an estimated 8.73 acres before reseeding. After reseeding only 2.39 acres of reseeded range was necessary to support one cow for one month, or a gain of 365 percent in capacity.

The scope of the study was not sufficient to be able to correlate failures with any particular variable. Only three areas could be considered as partial failures. On these areas precipitation over the October 1st to September 30th period, which measured the moisture falling on the newly seeded areas, was below the long-time average. The critical precipitation period of May to September which followed the reseeding period was unusually favorable.

An attempt was made to measure interest charges against returns. By one method, using two levels of grazing values and assuming the long-time value of beef (6), annual returns on 125 acres yielded $88.75 and $107.50 over the value of capital expended on the reseeding project. By budgeting the reseeding project within an average Intermountain cattle ranch, the reseeding project, after causing a net loss of $203.48 over a three-year

period, returned $105.22 in the fourth year. This return was assumed to accrue during the next fifteen years at an increasing amount due to the retirement of the investment in reseeding.

CONCLUSION

It is concluded that the reseeding of privately-owned spring-fall cattle range in Utah at the present time contains a large element of chance in the success or failure of the project. Owing to the limited physical factors of seedling establishment and growth on arid ranges and to assure the best chances for success, ranchers should apply for and receive help from reseeding experts in carrying out their individual programs. The experts have not yet developed procedures in reseeding to assure much more than an even chance of success merely from the physical production standpoint.

This study was made during a period of favorable climatic conditions. The reseeding operations, which were probably carried on by ranchers of above average abilities, resulted in what was thought to be above average returns. It is anticipated that improved physical techniques will eventually help the rancher with average ability to rehabilitate limited portions of his range needing improvement.

The present degree of popularity of range reseeding on private lands has been due in part to federal financial grants in sustaining part of the cost of the program. Before artificial range reseeding can be applied to private ranges on a wide scale it will be necessary to shift part of the emphasis from the purely physical to theeconomic factors. In setting up the research project the economic factors should be considered and weighed in much the same fashion as are the physical. When economic studies are accomplished at the same time that accurate calculations of grazing capacity and animal weight changes are made, then the results would have great

validity in answering questions on economic feasibility of range reseeding. Until an investment and return relationship is placed on range reseeding, it is doubtful if range reseeding can attain a permanent wide popularity on private lands among cattle ranchers of Utah.

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APPENDIX

Table 17: Annual Plant Year Precipitation for Utah State With the 1900 Through 1947 and the 1935 Through 1947 Averages

Year	Precipitation in Inches	Year	Precipitation in Inches
Year	Inches	Year	Inches
1900	9.03	1930	13.80
1901	10.44	1931	8.62
1902	8.36	1932	15.08
1903	11.17	1933	10.64
1904	11.76	1934	8.15
1905	12.73	1935	12.60
1906	17.07	1936	14.43
1907	16.48	1937	15.68
1908	14.38	1938	14.72
1909	18.17	1939	13.53
1910	12.76	1940	13.25
1911	13.82	1941	18.74
1912	12.26	1942	15.09
1913	13.79	1943	14.36
1914	15.00	1944	15.51
1915	12.82	1945	16.47
1916	13.44	1946	13.76
1917	15.79	1947	17.22
1918	12.83		
1919	11.27	Total Inches (1900-1947)	655.64
1920	15.28		
1921	17.24	Long-time Average	13.68
1922	15.01		
1923	14.73		
1924	9.30	Total Inches (1935-1947)	195.36
1925	14.62		
1926	11.75	Short-time Average	15.03
1927	15.31		
1928	11.07		
1929	16.21		

APPENDIX

Table 18: Supplementary Table for Figure 2 on Cost and Supply of Four Popular Western Range Grass Seeds.

Year	Stocks Held by Dealers and Government on June 30th							
	Stocks in 1000's of Pounds				Index of Stocks (1940-46 = 100)			
	Crested wheat-grass	Kentucky blue-grass	Smooth brome-grass	Slender wheat-grass	Crested wheat-grass	Kentucky blue-grass	Smooth brome-grass	Slender wheat-grass
	1000's pounds	1000's pounds	1000's pounds	1000's pounds	index	index	index	index 1/
1940	94	5,492	662	-	8	62	27	-
1941	523	9,007	218	-	42	101	9	-
1942	987	10,265	2,159	-	80	116	89	-
1943	863	19,466	4,147	157	69	219	171	38
1944	1,831	11,551	3,363	442	147	130	135	108
1945	3,667	4,232	2,537	682	295	48	105	167
1946	737	2,126	3,885	356	59	24	160	87
Total	8,702	62,139	16,969	1,637	700	700	700	400
Average	1,243	8,877	2,424	409	100	100	100	100

Year	Wholesale Prices of 100 Pounds of Seeds at a Large Western Seed Dealer							
	Price per 100 Pounds				Index of Price (1941-48 = 100)			
	Crested wheat-grass	Kentucky blue-grass	Smooth brome-grass	Slender wheat-grass	Crested wheat-grass	Kentucky blue-grass	Smooth brome-grass	Slender wheat-grass
	dollars	dollars	dollars	dollars	index	index	index	index
1941	14.00	23.50	15.00	17.00	61	49	71	90
1942	16.00	24.50	19.00	18.00	70	51	90	94
1943	14.00	21.00	15.00	15.00	61	44	71	79
1944	20.00	34.50	20.00	18.00	88	72	96	94
1945	20.00	38.50	21.00	18.50	88	80	100	97
1946	17.50	63.00	22.00	18.00	77	131	105	94
1947	34.50	120.00	31.50	23.50	151	249	150	123
1948	46.50	60.00	24.50	24.50	204	124	117	129
Total	182.50	385.00	168.00	152.50	800	800	800	800
Average	22.81	48.12	21.00	19.06	100	100	100	100

Source: Volume data is from Ag. Index, 1947, p. 290. Cost data is from seed catalogs of Kelley-Western Seed Co., Salt Lake City, Utah.

1/ Data for first three years not collected. Index based on 1943-1946 = 100.

APPENDIX

Table 19: Plant Year Precipitation at Fillmore, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	11.73	- 2.63	- 2.63	1925	14.92	0.56	6.87
1901	11.66	- 2.70	- 5.33	1926	10.72	- 3.64	3.23
1902	11.00	- 3.36	- 8.69	1927	14.10	- 0.26	2.97
1903	14.25	- 0.11	- 8.80	1928	11.37	- 2.99	- 0.02
1904	12.03	- 2.33	-11.13	1929	15.91	1.55	1.53
1905	15.12	0.76	-10.37	1930	15.63	1.27	2.80
1906	18.59	4.23	- 6.14	1931	8.60	- 5.76	- 2.96
1907	16.75	2.39	- 3.75	1932	15.29	0.93	- 2.03
1908	16.98	2.62	- 1.13	1933	14.06	- 0.30	- 2.33
1909	19.46	5.10	3.97	1934	5.94	- 8.42	-10.75
1910	12.20	- 2.16	1.81	1935	15.09	0.73	-10.02
1911	14.28	- 0.08	1.73	1936	17.27	2.91	- 7.11
1912	13.02	- 1.34	0.39	1937	15.58	1.22	- 5.89
1913	14.01	- 0.35	0.04	1938	12.65	- 1.71	- 7.60
1914	15.33	0.97	1.01	1939	12.34	- 2.02	- 9.62
1915	14.57	0.21	1.22	1940	14.02	- 0.34	- 9.96
1916	12.72	- 1.64	- 0.42	1941	15.63	1.27	- 8.69
1917	15.39	1.03	0.61	1942	14.40	0.04	- 8.65
1918	12.36	- 2.00	- 1.39	1943	11.61	- 2.75	-11.40
1919	11.66	- 2.70	- 4.00	1944	15.42	1.06	-10.34
1920	17.53	3.17	- 0.92	1945	20.13	5.77	- 4.57
1921	19.05	4.69	3.77	1946	14.42	0.06	- 4.51
1922	14.23	- 0.13	3.64	1947	18.79	4.43	- 0.08
1923	17.47	3.11	6.75				
1924	13.92	- 0.44	6.31				
Total					689.20	- 0.08	
Average					14.3583		
Total disregarding signs					689.20	100.24	229.97
Average disregarding signs					14.36	2.09	4.79
Coefficient of Variability of Sequence							2.29

APPENDIX

Table 20: Plant Year Precipitation at Logan, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	14.10	- 2.76	- 2.76	1925	19.31	2.45	1.67
1901	16.27	- 0.59	- 3.35	1926	16.01	- 0.85	0.82
1902	13.50	- 3.36	- 6.71	1927	17.65	0.79	1.61
1903	13.32	- 3.54	-10.25	1928	11.57	- 5.29	- 3.68
1904	14.95	- 1.91	-12.16	1929	17.88	1.02	- 2.66
1905	12.69	- 4.17	-16.33	1930	19.16	2.30	- 0.36
1906	23.70	6.84	- 9.49	1931	11.27	- 5.59	- 5.95
1907	20.62	3.76	- 5.73	1932	19.75	2.89	- 3.06
1908	16.30	- 0.56	- 6.29	1933	11.58	- 5.28	- 8.34
1909	20.70	3.84	- 2.45	1934	10.17	- 6.69	-15.03
1910	14.81	- 2.05	- 4.50	1935	14.08	- 2.78	-17.81
1911	19.68	2.72	- 1.78	1936	16.71	- 0.15	-17.96
1912	16.66	- 0.20	- 1.98	1937	20.03	3.17	-14.79
1913	19.07	2.21	0.23	1938	17.61	0.75	-14.04
1914	21.37	4.51	4.74	1939	16.10	- 0.76	-14.80
1915	15.73	- 1.13	3.61	1940	13.94	- 2.92	-17.72
1916	13.50	- 3.36	0.25	1941	18.12	1.26	-16.46
1917	24.21	7.35	7.60	1942	19.59	2.73	-13.73
1918	14.65	- 2.31	5.29	1943	18.37	1.41	-12.32
1919	12.90	- 3.96	1.33	1944	19.52	2.66	- 9.66
1920	18.32	1.46	2.79	1945	21.59	4.73	- 4.93
1921	10.27	- 2.41	5.20	1946	18.93	2.07	- 2.86
1922	18.32	1.46	6.66	1947	19.87	3.01	0.15
1923	16.58	- 0.28	6.38				
1924	9.70	- 7.16	- 0.78				
Total					809.53	0.15	
Average					16.86		
Total disregarding signs					809.53	135.45	329.05
Average disregarding signs					16.86	2.82	6.86
Coefficient of Variability of Sequence							2.43

APPENDIX

Table 21: Plant Year Precipitation at Tooele, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	12.40	- 4.31	- 4.31	1925	18.38	1.67	13.07
1901	13.74	- 2.97	- 7.28	1926	17.27	0.56	13.63
1902	10.56	- 6.21	-13.49	1927	16.69	- 0.02	13.61
1903	12.09	- 4.62	-18.11	1928	12.63	- 4.08	9.53
1904	20.09	3.38	-14.73	1929	19.70	2.99	12.52
1905	13.41	- 3.30	-18.03	1930	16.19	- 0.52	12.00
1906	20.11	3.40	-14.63	1931	11.83	- 4.88	7.12
1907	16.31	- 0.40	-15.03	1932	15.47	- 1.24	5.88
1908	22.14	5.43	- 9.60	1933	14.91	- 1.80	4.08
1909	22.80	6.09	- 3.51	1934	10.56	- 6.15	- 2.07
1910	12.43	- 4.28	- 7.79	1935	13.95	- 2.76	- 4.83
1911	13.57	- 3.14	-10.93	1936	17.41	0.70	- 4.13
1912	17.09	0.38	-10.55	1937	18.74	2.03	- 2.10
1913	22.95	6.24	- 4.31	1938	17.37	0.66	- 1.44
1914	19.09	2.38	- 1.93	1939	12.87	- 3.84	- 5.28
1915	17.94	1.23	- 0.70	1940	13.23	- 3.48	- 8.76
1916	16.82	0.11	- 0.59	1941	19.70	2.99	- 5.77
1917	20.28	3.57	2.98	1942	19.66	2.95	- 2.82
1918	13.68	- 3.03	- 0.05	1943	14.54	- 2.17	- 4.99
1919	11.73	- 4.98	- 5.03	1944	18.89	2.28	- 2.71
1920	23.05	6.34	1.31	1945	19.00	2.29	- 0.42
1921	23.83	7.11	8.42	1946	14.01	- 2.70	- 3.12
1922	20.68	3.97	12.39	1947	19.67	2.96	- 0.16
1923	20.59	3.88	16.27				
1924	11.84	- 4.87	11.40				
Total					801.89	- 0.16	
Average					16.71		
Total disregarding signs					801.89	151.34	353.41
Average disregarding signs					16.71	3.15	7.36
Coefficient of Variability of Sequence							2.34

APPENDIX

Table 22: Plant Year Precipitation at Manti, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	9.77	- 2.57	- 2.57	1925	11.51	- 0.83	9.10
1901	8.40	- 3.94	- 6.51	1926	10.80	- 1.54	7.56
1902	7.72	- 4.62	-11.13	1927	11.85	- 0.49	7.07
1903	11.03	- 1.31	-12.44	1928	8.67	- 3.67	3.40
1904	10.57	- 1.77	-14.21	1929	12.77	0.43	3.83
1905	15.74	3.40	-10.81	1930	13.73	1.39	5.22
1906	18.31	5.97	- 4.84	1931	6.22	- 6.12	- 0.90
1907	15.38	3.04	- 1.80	1932	9.97	- 2.37	- 3.27
1908	14.02	1.68	- 0.12	1933	7.85	- 4.49	- 7.76
1909	16.37	4.03	3.91	1934	7.04	- 5.30	-13.06
1910	10.99	- 1.35	2.56	1935	12.04	- 0.30	-13.36
1911	13.09	0.75	3.31	1936	15.00	2.66	-10.50
1912	11.76	- 0.58	2.73	1937	13.84	1.50	- 9.00
1913	13.49	1.15	3.88	1938	11.58	- 0.76	- 9.76
1914	17.08	4.74	8.62	1939	11.95	- 0.39	-10.15
1915	11.32	- 1.02	7.60	1940	12.11	- 0.23	-10.38
1916	12.52	0.18	7.78	1941	15.53	3.19	- 7.19
1917	14.24	1.90	9.68	1942	10.87	- 1.47	- 8.66
1918	11.33	- 1.01	8.67	1943	12.06	- 0.28	- 8.94
1919	11.80	- 0.54	8.13	1944	15.14	2.80	- 6.14
1920	14.09	1.75	9.88	1945	15.72	3.38	- 2.76
1921	15.91	3.57	13.45	1946	11.20	- 1.14	- 3.90
1922	12.31	- 0.03	13.42	1947	16.33	3.99	0.09
1923	11.39	- 0.95	12.47				
1924	9.80	- 2.54	9.93				
Total					592.41	0.09	
Average					12.34		
Total disregarding signs					592.41	103.31	352.45
Average disregarding signs					12.34	2.15	7.34
Coefficient of Variability of Sequence							3.41

APPENDIX

Table 23: Plant Year Precipitation at Monticello, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	2.50	-11.85	-11.85	1925	20.74	6.39	-11.72
1901	3.48	-10.87	-22.72	1926	15.40	1.05	-10.67
1902	6.13	- 8.22	-30.94	1927	20.01	5.66	- 5.01
1903	12.91	- 1.44	-32.38	1928	15.59	1.04	- 3.97
1904	10.37	- 3.98	-36.36	1929	21.66	7.31	3.34
1905	13.76	- 0.59	-36.95	1930	13.84	- 0.51	2.83
1906	13.97	- 0.38	-37.33	1931	12.64	- 1.71	1.12
1907	8.02	- 6.33	-43.66	1932	20.62	6.27	7.39
1908	8.97	- 5.38	-49.04	1933	12.71	- 1.64	5.75
1909	14.41	0.06	-48.98	1934	9.73	- 4.62	1.13
1910	10.15	- 4.20	-53.18	1935	14.54	0.19	1.32
1911	22.94	8.59	-44.59	1936	10.82	- 3.53	- 2.21
1912	21.27	6.92	-37.67	1937	15.59	1.24	- 0.97
1913	18.88	4.53	-33.14	1938	14.23	- 0.12	- 1.09
1914	18.52	4.17	-28.97	1939	13.55	- 0.80	- 1.89
1915	19.33	4.98	-23.99	1940	14.53	0.18	- 1.71
1916	18.68	4.33	-19.66	1941	21.26	6.91	5.20
1917	24.21	9.86	- 9.80	1942	16.13	1.78	6.98
1918	13.43	- 0.92	-10.72	1943	11.58	- 2.77	4.21
1919	14.48	0.13	-10.59	1944	13.08	- 1.27	2.94
1920	20.85	6.50	- 4.09	1945	12.22	- 2.13	0.81
1921	14.42	0.07	- 4.02	1946	13.66	- 0.69	0.12
1922	8.44	- 5.91	- 9.93	1947	14.01	- 0.34	- 0.22
1923	9.82	- 4.53	-14.46				
1924	10.70	- 3.65	-18.11				
Total					688.58	- 0.22	
Average					14.35		
Total disregarding signs					688.58	176.54	755.73
Average disregarding signs					14.35	3.68	15.74
Coefficient of Variability of Sequence							4.28

APPENDIX

Table 24: Plant Year Precipitation at St. George, Utah Showing Calculation of Coefficient of Variability of Sequence

Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation	Year	Inches of Precipitation	Deviation from Mean	Cumulative Deviation
Year	Inches	Inches	Inches	Year	Inches	Inches	Inches
1900	15.02	5.83	5.83	1925	9.48	0.29	11.93
1901	8.16	- 1.03	4.80	1926	8.05	- 1.14	10.79
1902	7.87	- 1.32	3.48	1927	11.42	2.23	13.02
1903	8.34	- 0.85	2.63	1928	6.93	- 2.26	10.76
1904	6.58	- 2.61	0.02	1929	7.55	- 1.66	9.10
1905	13.00	3.81	3.83	1930	7.75	- 1.44	7.66
1906	10.90	1.71	5.54	1931	8.55	- 0.64	7.02
1907	12.62	3.43	8.97	1932	15.77	6.58	13.60
1908	11.25	2.04	11.01	1933	5.13	- 4.06	9.54
1909	12.92	3.73	14.74	1934	6.27	- 2.92	6.62
1910	9.23	0.04	14.78	1935	9.99	0.80	7.42
1911	10.36	1.17	15.95	1936	7.39	- 1.80	5.62
1912	7.15	- 2.04	13.91	1937	10.13	0.94	6.56
1913	11.88	2.69	16.60	1938	7.10	- 2.00	4.56
1914	9.39	0.20	16.80	1939	9.99	0.80	5.36
1915	9.73	0.54	17.34	1940	8.06	- 1.13	4.23
1916	14.24	5.05	22.39	1941	13.48	4.29	8.52
1917	9.01	- 0.18	22.21	1942	8.75	- 0.44	8.08
1918	7.61	- 1.58	20.63	1943	10.38	1.19	9.27
1919	6.72	- 2.47	18.16	1944	6.43	- 2.76	6.51
1920	9.81	0.62	18.78	1945	7.10	- 2.09	4.42
1921	8.72	- 0.47	18.31	1946	5.22	- 3.97	0.45
1922	10.04	0.85	19.16	1947	8.68	- 0.51	- 0.06
1923	6.69	- 2.50	16.66				
1924	4.17	- 5.02	11.64				
Total					440.97	- 0.06	
Average					9.19		
Total disregarding signs					440.97	97.72	495.27
Average disregarding signs					9.19	2.04	10.32
Coefficient of Variability of Sequence							5.07